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THE CULTURE AND MARKETING OF TEA

PLUCKING TEA IN NORTH-EAST INDIA

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THE CULTURE AND MARKETING OF TEA

BY

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TO

A.W.H.

'this healthful Herb'

J. Ovington, *Essay upon Tea,* 1699

PREFACE

THIS book does not pretend to be an exhaustive treatise on tea, but attempts to put on record the experience gained during the fourteen years I have been connected with the tea industry in North-East India. This time was spent in working as a scientist for the Indian Tea Association, a post involving laboratory and field work at the Experimental Station and Estate at Tocklai, Assam, and also necessitating regular visits to the tea gardens of Assam and Bengal. These visits were made with a view to disseminating the findings and opinions of the Scientific Department of the Association, and to link up theory with garden practice.

The subject is dealt with in four parts. The first gives a general account of the tea plant, its cultivation and manufacture. The second deals with the chemistry and pharmacology of tea, and may be of little interest to the practical man. The third part describes the methods adopted in the chief tea countries of the world, especially those employed in North-East India, to which area four chapters are devoted. In the first of these, entitled 'North-East India', I have attempted to describe various aspects of the country not necessarily closely connected with tea, but naturally having some bearing upon the subject. The last part of the book consists of two short chapters on the British tea trade, in which the present position of the industry is summarized. This aspect of the subject I have been prompted to touch upon because of the crisis through which the industry, in common with most others, is at present passing.

Although I have visited the tea districts of Ceylon, Java and Japan, I write from the point of view of

conditions in North-East India. On this account certain aspects of the subject may seem laboured, but this is because they are of particular interest to the planter in India. Other questions of importance perhaps in other tea countries, are lightly touched on because they do not assume prominence in India.

The chapters dealing with tea in China, Japan, Ceylon and Java should be regarded as descriptive rather than authoritative. It is obviously outside the capacity of the visitor to a tea country to speak with authority on general practice in that country.

Much of the matter presented has been published at some time or other in the Quarterly Journal of the Scientific Department of the Indian Tea Association. My thanks are due to the Association, to Mr. R. O. Mennell and to Messrs. Davidson & Co., Ltd., for permission to use several photographs, and to Mr. Jas. Insch for access to his library of books on tea.

C. R. HARLER

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THE TEA PLANT

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Tea is made from the young shoots of the tea plant, *Thea sinensis* (L) Sims, a species which includes some very distinct varieties.

The use of an infusion of dried tea leaf as a beverage has its origin in antiquity and, according to existing records dating back many centuries, tea was first cultivated and made in China. It is quite possible, however, that tribes in the Shan States, led by that instinct which prompts even primitive peoples to make use of alkaloid yielding plants, have used tea in some form or other as long as the Chinese.

According to the method of preparation of the leaf, the tea is designated green or black, the former also being known as unfermented and the latter as fermented tea. The tea most commonly used in the west is black. A semi-fermented tea, known as Oolong, is also prepared in Formosa and south China. The Shan tribes pickle the leaf and make what is known as 'leppet' tea, which is not exported.

Tea leaf is rich in the alkaloid caffeine, which may constitute as much as 4 per cent of the dry matter in the leaf, and in tea tannin, which in some varieties of tea makes up almost one-third of the dry matter of the younger leaves.

Tea is drunk primarily on account of the stimulus given by the caffeine. Some tea drinkers, like the

British and Australians, have acquired a taste for the tannin in black tea and, although fully appreciative of the stimulus given by the beverage, judge a tea largely by the 'strength' of the infusion.

The Habitat of the Tea Plant

The original home of the tea plant is the subject of conjecture and one which is hardly likely ever to be settled conclusively. It is to China that we are indebted for our first knowledge of tea and tea manufacture, and for the first seeds and plants grown by Europeans in Java and India. Yet this vast country is so inaccessible and imperfectly known except on the habitual routes, and the character of its inhabitants is such, that it is extremely difficult to obtain any trustworthy information on the scientific question whether this or that plant grows wild. This is more especially so when the plant in consideration, that is tea, has been cultivated for many centuries.

In Assam, about a hundred years ago the tea plant was found growing in a state thought to be wild, and tea was at this time prepared by the natives. However, to-day some doubt exists regarding the plain of the Brahmaputra Valley as the home of tea, since the natural tea tracts have not been preserved and from early accounts it seems that much of the tea found was planted in regular patches.

In Upper Burma and Upper Siam, in the area spoken of as the Shan States, tea plants, apparently not cultivated but arranged in orderly groups, have been found. The same can be said, although with less certainty, of the island of Hai-nan.

Absolutely wild tea plants, unemployed by aborigines, have been discovered at Meng-tze in south Yun-nan, and in the adjoining country of Upper Tong-king, in

French Indo-China. Large leaved varieties have similarly been found in the hills round Manipur.

Wild tea also occurs in Laos, in French Indo-China, where the natives prepare the leaves in the Chinese manner.

Many accounts, some not very reliable, of tea plants both wild and cultivated have been given by travellers in various parts of south-east Asia, and numerous specimens can be seen in the herbaria at Kew, Berlin and elsewhere. From the accounts and the specimens it appears that the varieties of tea fall into certain groups or forms, which will be described later.

The questions now to be considered are, whether the localities cited above are likely to be the original home of the tea plant, and whether the geographical distribution accounts for the diversity of forms, i.e. whether all the varieties can be traced to one parent form, and if so, where this parent originated.

Practically all the areas where tea is said to grow wild are situated along big rivers, the Yang-tsi-kiang and Tsi-kiang in China, the Song-koi or Red river in Yun-nan and Tong-king, the Mekong in Yun-nan, Siam and French Indo-China, the Salween and Irawadi in Yun-nan and Burma, and the Brahmaputra in Assam. Since all these rivers or their tributaries spring from the complex mountain system which buttresses the eastern end of the Tibetan plateau, it has been suggested that these mountains represent the distribution centre of the tea plant.

This theory is refuted by Cohen Stuart[1] who considers that the typical China tea plant (described later under Group 1 of his classification of tea varieties) arose independently of the other larger leaved varieties. China has a flora which is much more its own than is the

[1] 'A Basis for Tea Selection', by C. P. Cohen Stuart, *Bull. du Jardin Botanique de Buitenzorg*, Weltevreden (1919), Vol. I, fasc. 4. This work gives a masterly account of the distribution and botany of tea.

more widely distributed flora of Indo-China, Burma and Assam. Thus there is a large leaved tea plant in Manipur and definite evidence of a large leaved China tea in Yun-nan, which is orographically a continuation of Indo-China. No large leaved tea plant has been found or described, however, in east or south-east China. Accordingly, it is suggested that the typical China plant originated and developed amongst the other *Camellias* and *Theas* growing in east and south-east China, to which it shows a much closer resemblance than to western tea forms. Cohen Stuart agrees that the large leaved varieties of tea may have spread from the mountains to the east of Tibet.

In his search for the original home of the tea plant, Cohen Stuart has considered the transportation of tea by man. Tea plants have been found near the important caravan routes between China and India. Transportation and hybridization have generally been southward in Yun-nan and westward in Burma. There is some evidence, of a doubtful nature, that tea has been transported eastward from Sze-chuan into China. The three localities mentioned are included in the areas which give rise to larger leaved varieties of tea. The typical China plant, of east and south-east China, has suffered less blending than other varieties and has remained comparatively true bred, whilst the tea in the Shan States of Burma and Siam is the most hybridized. Assam indigenous tea has also been subject to influence from without, especially during the nineteenth century when much China tea was imported. On the other hand, it seems that Manipur, Cachar and Lushai teas, which differ so much from other large leaved varieties, have been preserved from the taint arising from migration.

Although in earlier years it was difficult to get a general impression of central Asiatic vegetation *in loco*,

on account of inaccessibility, the building of railways into the very centre of the regions of greatest interest to plant geographers has, whilst making travel easy, ruined all chance of the final solution of such problems as are here under discussion. As communications develop so the natural vegetation of an area is modified. China, Burma and Assam have been so extensively opened up that little hope remains of making further progress with the subject in these countries, but in French Indo-China, where wild tea varieties still exist, important clues regarding the origin of the tea plant may yet be found.

On the evidence available, Cohen Stuart considers that there exist at least two morphological groups of tea plants, one indigenous to east and south-east China and the other to an indefinite area located to the south-east of the Tibetan plateau, and including Sze-chuan, Yun-nan, Tong-king, Siam, Burma and Assam. There is no evidence supporting the idea of any direct genetical or genealogical affinity between them.

The Name of the Tea Plant

The two extreme varieties of the tea plant, the small leaved true China and the large leaved India types, present the following characteristics.

China	India
Bush, dwarfed	Tree, loosely branched
Flowers early and plentifully	Flowers late and poorly
Leaf rarely larger than $3\frac{1}{2}$ by $1\frac{1}{8}$ inches	Leaves generally larger than $4\frac{3}{4}$ by $1\frac{1}{4}$ inches
Lateral veins 8 to 10 pairs	Lateral veins 10 to 14 pairs
Relative number of serrations generally above 30	Relative number of serrations generally under 30
Top leaf often tinged red	Top leaf green or yellowish green
Leaf surface as a rule smooth	Leaf often bullate (blistered, puffy)

Supported by such diagnoses as the above, two well characterized varieties may be established. When intermediate types have to be classified difficulty arises, and much confusion in the systematic botany of tea has resulted.

Linnaeus in his Species Plantarum (1753) formed two genera, *Thea* and *Camellia,* which enter into this discussion. At that time only one species of the former genus, viz. *Thea sinensis,* the tea plant of China, and two of the latter, viz. *Camellia japonica* and *C. sassanqua* were known.

In 1762 two varieties of tea, *Thea viridis* and *T. bohea,* were distinguished by Linnaeus, the former being the plant thought to be used in the manufacture of green tea, and the latter of black tea. Later it was shown that both green and black tea were made from the same plant which was then called *Thea bohea.* Confusion started from this time and increased as each botanist took up the problem. Almost a score of species and varieties have been described and named at some time or other, although from time to time attempts have been made to classify all the varieties under one species.

Sir George Watt, the most notable botanist to study tea during the latter part of the last century and the early part of the present, considered all tea plants to belong to one species which he called *Camellia thea* (Link) Brandis, a name first used by Link in 1822, and applied by Brandis in 1874 to both China and India tea plants.

In 1919, Cohen Stuart, dealing with the systematic botany of tea, also considered that all teas should be grouped under one species, and the name he chose was *Camellia theifera* (Griff.) Dyer. This name was first used by Griffith in 1854 to denote Assam tea, and was employed by Dyer in January 1874, a few months ahead of Brandis, to denote both China and India tea plants.

There are definite rules laid down for fixing the name of a plant when there is a choice of several names already in existence. For many years botanists have combined the two genera *Thea* and *Camellia* on account of the close relationship between the species included in the two. According to international rules for the naming of plants, when two or more groups are united the name of the oldest is retained. Furthermore, botanical nomenclature is considered to begin with the Species Plantarum of Linnaeus, published in 1753. The genus *Thea* was mentioned by Linnaeus before *Camellia* and the first name used for tea was *Thea sinensis*. Therefore since it has been agreed to consider tea plants as belonging to one species, the original name used by Linnaeus must be retained. The name was first used to denote the tea bush of China, but was used by Sims in 1807 to include all the varieties then known under one species. The origin of the term is denoted by placing the letter L, for Linnaeus, and the name of Sims after the name of the plant. The full name thus becomes *Thea sinensis* (L) Sims.

The Varieties of the Tea Plant

To a great extent it is a matter of convenience whether we speak of varieties or species, and the question of the differentiation between the two should not be invested with undue importance. The classification of the varieties of tea by two botanists will be described.

Sir George Watt recognized four varieties within the species, which he called viridis, Bohea, stricta and lasiocalyx. Within the variety viridis he recognized six races of tea, Assam indigenous, Lushai, Naga Hills, Manipur, Burma and Shan, and Yun-nan and Chinese. Later on he considered the viridis (large leaved) and lasiocalyx (small leaved) to be the two main varieties

from which Bohea and stricta were obtained by hybridization. For a description of each variety and race reference must be made elsewhere,[2] but it may here be noted that this classification is one which might well have been adopted had it been published in a journal easily accessible to systematic botanists.

After examining all the descriptions of tea varieties published and the specimens available in the more important herbaria, Cohen Stuart considers that within the species four main groups of tea plants can be recognized.[3]

The first group comprises the varieties of the small leaved, true China plant. The other three groups include the larger leaved plants occurring in the countries bordering on the Tibetan plateau and in Indo-China. Details of the four groups are as follows.

Group 1. China, variety *Bohea*. Small leaves, 1½ to 2½ inches long, leaf stiff, leathery, usually deeply coloured with 6 to 8 pairs of veins which are not very prominent; leaves usually without a definite apex. This group occurs in east and south-east China and Japan.

Group 2. Variety *macrophylla* v. Siebold. Large leaves up to 5½ inches long. Trees up to 16 feet high. Number of veins about 8 or 9 pairs; no leaf apex. Occurs in Hu-peh, Sze-chuan and Yun-nan.

Group 3. Shan form, perhaps related to 'Assam' tea. Large leaf up to 6½ inches long. Trees 15 to 30 feet high. Leaf light coloured with about 10 pairs of veins and continuous apex. Occurs in Tongking, Laos, Upper Siam, Upper Burma (collectively known as the 'Shan' lands), also possibly Assam.

[2] G. Watt, 'Tea and the Tea Plant,' *Jour. Roy. Hort. Soc.* (1907), vol. 32, p. 64. G. Watt, 'Commercial Products of India,' London (1908), p. 209.

[3] C. P. Cohen Stuart, Thee, *Camellia theifera* (Griff.) Dyer, *Frühwirth Handbuch landw. Pflanzenzüchtung.*

Group 4. Variety *assamica.* Very large leaves, 8-12 inches and even up to 14 inches in length. Trees up to 60 feet high. Leaves comparatively thin and flaccid, moderately dark green, with 12 to 15 pairs of veins, which are very prominent and result in the striking wrinkling of the leaf surface; moderately long, sharply defined apex. Occurs in Manipur, Cachar, Lushai.

THE 'FLUSHING' OF TEA

The tea plant is an evergreen which, given a sufficiently high temperature and humid conditions, grows all the year round. In North-East India, where the seasons show considerable variation, the growth of the plant is as follows. In the cool, dry season growth is very slow indeed and on most of the shoots the leaf buds become dormant. In spring new leaf growth appears both from dormant shoots and from leaf axils. Provided there is sufficient rain this growth continues, otherwise it wilts and finally dies back. When rain comes, fresh growth appears and, so long as rain is plentiful, vigorous growth continues till late autumn, when both temperature and humidity fall. The leaf buds then become dormant, the axils cease to produce new shoots, and growth is negligible from the practical point of view.

The young leaf is called the 'flush' by tea planters, and is soft and succulent, and light yellowish green in colour. When growth begins either from a dormant leaf-bud or from an axil, the first leaf is not a true one, but a bract which often shrivels and falls off. The bract may be followed by a larger but still malformed leaf or prophyll. These imperfect leaves, which are more oval than the ordinary leaf and have no serrations and no definite apex, are called *janum* (Assamese—birth) leaves in India and 'fish leaves' in Ceylon. The bigger

prophylls are also called *gol-pat* (Assamese—round leaf) in Assam.

The *janum* is an important position on the stem so far as plucking is concerned, and acts as a mark by which the severity of the plucking is judged. This aspect of the subject is dealt with in a later chapter.

The leaves are arranged round the stem of a tea plant in spirals in such a manner that five leaves form a series which encircle the stem twice, and the 6th leaf appears above the first of the previous series. This leaf arrangement, or phyllotaxis, is described as a 2-5 system, the 5 referring to the number of leaves which make up the system and the 2 denoting the number of times the stem is encircled to complete the series.

On a strong, vigorous branch in the centre of the bush the shoot grows continuously at a rate which varies from time to time. On a weak or side branch, the shoot may become dormant after growing several leaves, and cease to develop for the time being. Such a state is described in North-East India as *banjhi* (Assamese—sterile), and usually occurs after the growth of about five leaves, i.e. the completion of a series described above. The dormant period may last up to eleven weeks, after which the bud produces a series of leaves again, preceded by *janum* leaves in a manner similar to that observed when the axillary bud develops. An examination of the side branch of a tea bush in Assam may reveal several series of five leaves, each series separated from the next by a prophyll.

With a very strong branch it is possible for growth to continue without any definite dormant period throughout the greater part of the season. In Ceylon and Java, where general growth is continuous throughout the year, marked dormancy is taken to indicate a need for pruning.

When a bush is plucked the tendency to dormancy is reduced, but it can never be completely overcome by plucking or by any other method known at present.

The distance between the leaves on a tea shoot varies from about half an inch in China varieties to about 2 inches in Assam varieties. In some cases where leaf is grown in the shade, with great rapidity, it is common in North-East India for the inter-leaf space to be as great as 6 inches.

The leaf bud and the under side of the very young leaves of the shoot are covered with fine hairs. During the preparation of black tea the expressed juices are smeared on these hairs which present a yellow appearance on drying. In the black mass of the tea these fine hairy parts show up yellow, and are spoken of as the 'tip'. A tea containing much 'tip' is usually highly valued.

The Tea Flower

Sufficient has been said of the leaf and general form of the tea plant to indicate that a diagnosis to cover the collective species must be a very general one. It is now proposed to describe the tea flower.

The flower buds are globular on pendulous stalks, originating from either side of the axillary buds. They occur singly or in pairs, but sometimes as many as five are grouped together. They are white and fragrant and about 1¼ inches in diameter.

The calyx, or outer case of the flower, is leathery and glossy, consisting of five to seven sepals. The petals, equally five to seven, are hairless, obovate and externally convex, fusing at their base with each other and with the stamens, and falling off with the stamens as a whole.

The stamens are very numerous, and united at their base. The ovary or seed vessel is three- or four-celled and is coated with shining white hairs. The style is free

from hair and, as a rule, split the top third of its length, and sometimes down to the ovary. The length of the style is about two-fifths of an inch.

The fruit is hairless, about 1 inch in diameter and one to four-lobed, according as the seeds have set in one or more cells. There are one to three seeds in each cell, and one to six seeds in each fruit. The seed is dark brown, about half an inch in diameter, almost smooth, spherical or mutually flattened.

The tea flower as defined above differs from other *Thea* species in the following respects: (1) The stalked, drooping flowers; (2) the permanent calyx; (3) the white petals, not emarginate and as a rule hairless; (4) the stamens are united only at their base; (5) the hirsute ovary and hairless style; and (6) the 3 or 4-lobed fruit.

Tea is practically always cross-fertilized and flowers only self-fertilize with difficulty. The significance of this fact is that the seed from any bush is liable to produce a hybrid plant unless care is taken to ensure that the pollen from bushes of the same variety only is available for pollenization.[3]

The need for planting seed-bearing trees in isolated places thus becomes apparent. Most commercial varieties or 'jats' as they are known, are more or less mixed and, indeed, so far as North-East India is concerned little care is taken to keep seed gardens isolated. Writing on this aspect of the subject, Cohen Stuart says: 'Carelessness about the variety of tea planted, carelessness about the precious wild tea tracts, carelessness about the management of seed gardens, carelessness, in short, about all measures that are liable to ensure an effective tea selection, such, I regret to say, has been the happy-go-lucky attitude of the British planters towards a matter which could not yield immediate profits, but should undoubtedly have done so at one time or another.

Nor did they lack good counsel, for Sir George Watt has, ever since 1882, endeavoured to reorganize the Assam tea gardens.'[4]

How far this rebuke is merited it is difficult to say, for it is probable that hybridization had been going on before the planter arrived. Hybridization with China plants in the last century was an unfortunate incident in Assam, but in keeping with scientific opinion of that time. On the advice of Griffith, the botanist, Assam and China tea were interplanted 'in order to work up or reclaim the Assam plant as rapidly as possible'.

Tea Selection

No scientific selection of tea has been carried out in India, although from about 1880 to the end of the nineteenth century Dr. (later Sir George) Watt made many visits to Assam and advised the planters regarding the selection of what came to be known as the 'Assam indigenous' plant. Certain recognized stocks, e.g. Kalline, Bazaloni, Singlo, Namsang and Tingrai, became well known, and the jat known as Rajghur, selected by Dr. Watt himself, made and kept a reputation of high value.

There are many fine seed gardens in North-East India to-day. The plants are usually selected on general appearance regarding health, freedom from disease, shape and colour of leaf. The jat is usually known by the name of the garden which produces it, and the reputation of a jat is founded on its success in practice.

For commercial purposes in North-East India, the jats are divided into six groups, the light leaved or Assam indigenous, the dark leaved or Manipuri, hill Burma, China, Hydrid and Lushai. The last three groups are not planted nowadays and there is no call for the seed. During

4 'A Basis for Tea Selection,' p. 206.

the past few years, however, there has been a demand for China seed from the Caucasus, where tea is being planted, which has led to a brisk trade in this commodity from gardens in the Darjeeling district. The seeds in this case are mainly taken from bushes in plucking, for there are few seed gardens in Darjeeling.

The Assam indigenous plant is particularly suited to conditions in the Brahmaputra Valley, whilst the dark leaved variety is suited to the more severe climatic conditions of the Surma Valley and the Dooars. The hill Burma seed is collected in the hills round Manipur, and the plants grown from this seed are liable to show a wide variation in type.

In Java a considerable amount of scientific work has been carried out on the subject of tea selection and this it is proposed to describe in some detail.

From the seeds of commercial jats as used in North-East India and exported to other tea countries, the botanists in Java set about selecting pure strains. Selection from plants grown from seed is a very lengthy process in the case of tea which takes not less than three years to produce seed and usually longer. On this account vegetative propagation was employed.

Assuming that a pure strain has been selected it is then necessary to guard against cross fertilization with other strains. Observations made in Java indicate that the pollen of the tea flower is liable to be carried by insects over a distance somewhat less than a kilometre and, accordingly, the seed gardens in the selection experiments were isolated from each other by a walk of at least ten minutes. This distance was considered adequate to prevent the crossing of one strain with another. The sites of the seed gardens were chosen in the jungle at Tjinjiroean, on the Pengalengan plateau in Central Java, at attitudes varying from 5,000 to 6,500 feet. No

less than 22 sites, each of 2½ to 4½ acres in extent, were selected.

Of the 22 areas, 19 were put out with jats imported from India and 3 with Java grown tea. The Indian seed includes the commercial varieties known as Ghoirali (2 areas), Rajghur, sometimes called Dr. Watt's variety (2 areas), Ghiarkhatta, Mitanguri, Singlo Hill (2 areas), Jaipur, Bazaloni, Itakhuli, Nakhati, Manipuri, Kalline, Alyne, Dhonjan, Kutchu, Goipani, and a pseudo Itakhuli, from Itakhuli stocks and Ghoirali scions. The Java seed includes Tjiliwong, Malabar and Kiara Pajoeng.

After two years in the nursery the plants were carefully selected for leaf characteristics, regularity of branching, height, freedom from diseases like Brown blight and Pink disease, and were replanted 6 feet apart. Four years after replanting, a second selection was made according to leaf characteristics, freedom from Corticium and root diseases. In the seventh and eighth years further selections were made.

By this method of stringent selection, only 250 trees were left in the 22 gardens, and these were used as parent trees in the grafting work which followed. Details of the experiments on grafting and on the kind of graft best suited to tea will be detailed later.

The seed gardens at Tjinjiroean as they now stand consist of magnificent trees of a regularity seldom seen in seed gardens of North-East India. It was found that the Ghoirali, Kalline and Rajghur jats gave the greatest success with grafting. Bazaloni was difficult to graft because of the thin cambium.

Yet, interesting and important as is the selection work carried out, it has been observed that there is practically no correlation between jat and crop, and that Assam or Burma bushes with small leaves, usually

assumed to be poor jat, may yield more than many of those of better jat. Accordingly, another selection scheme is being worked out in which scions were taken from high yielding bushes irrespective of jat.

The value of vegetative propagation will be appreciated, although the possibilities are not so great as with other crops where less plants per acre are employed, e.g. rubber and cinchona. So far as tea is concerned, it will certainly pay to put out seed gardens by means of grafts from selected plants. Again, it may be of great assistance to use an absolutely uniform area of tea for pruning, plucking and similar experiments, and in such a case regularity obtained by grafting might be worth while.

The Vegetative Propagation of Tea

Before the selection experiments just described were carried out it was necessary to establish a method of vegetative propagation suited to tea. At Tjinjiroean many methods were tried, viz. crown, cleft and splice grafting, layering, inarch and upright stem layering, and various kinds of budding and veneering. The results showed that crown grafting, budding and upright stem layering were the best, and a brief reference to these three methods will now be made.[5]

Crown grafting. Best made on a six- or seven-year old stock which is sawn off some inches from the ground and allowed to grow three or four strong shoots. After 18 months or 2 years these shoots, which should not be less than about 2 inches in diameter 6 inches above the stump, should be cut squarely at the latter height. After an interval of one to three days, when excessive bleeding has ceased, the grafting is done.

[5] A. A. M. N. Keuchenius, *The Vegetative Propagation of Tea*, Buitenzorg.

Young plants, two years old in the nursery, may also be grafted by inserting the scion on the stem instead of on a two-year old shoot from the stubbed stem as described above. Direct grafting in this manner is, however, less successful than the other.

The scion used in crown grafting must be a vigorous young shoot, the best ones coming from 6 to 12-year old trees, which during the rainy season yield as many as 50 to 150 scions per month. The best scions are the top shoots of the main stems. These young shoots are cut 8 to 10 inches long and the leaves are cut back to three-quarters of an inch, leaving the buds in the axils. They should be grafted as soon as possible, but if stored in a damp place, wrapped in moss or ferns, they may be kept for two days. The part of the shoot between the fourth and eighth leaves, counting from the top, is made use of for cutting scions.

The stage of development of the buds of the scion is of great importance. They should be at that stage when their tegment leaflets are standing quite apart, whilst the top of the young bud should be clearly visible between the expanding bracts.

Before fixing the graft the top of the sawn stock is made smooth with a pruning knife. At the top of the stump a smooth portion of the bark, without dormant buds, is chosen for inserting the graft. The graft is bound to the stock by very thin strips of damp bamboo, and the mounted graft carefully covered with wax.

After grafting, young shoots growing from the stock must be cut away every few weeks for the first few months. The grafts should be shaded.

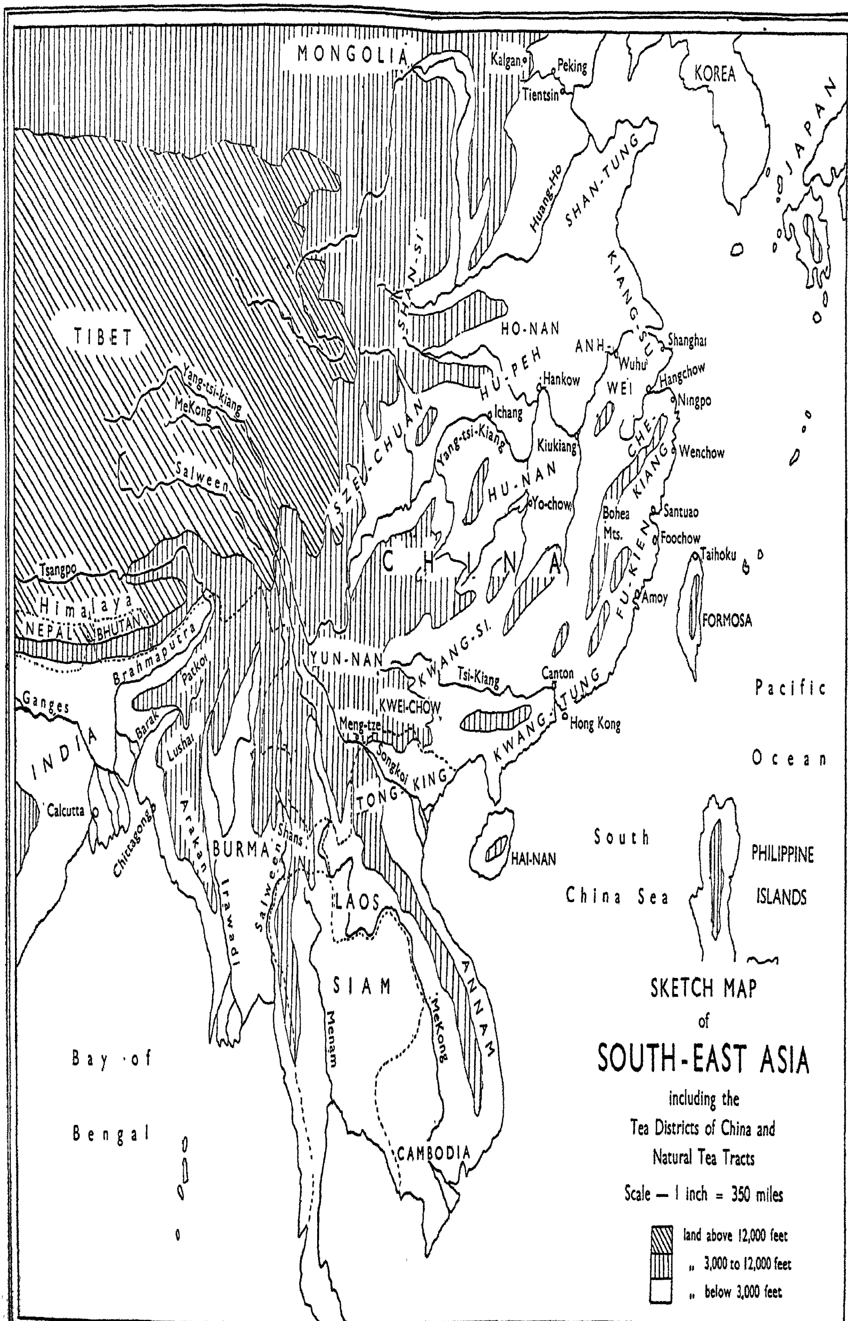
Budding. This may be done on the main stems of two- to four-year old plants in nurseries or seed gardens, on the lower side branches of stumped bushes, or on two-

to four-year old shoots of stumped bushes. Budding should be carried out as low as possible on the stem or branch, which must be kept free from side growth for a certain distance during the year before budding.

The buds should be taken from branches 4 to 8 inches in circumference with a good number of dormant buds. The bark of the budding wood should not be thin, and should be at least as thick as that of the stock. Only dormant buds should be made use of.

The buds are cut and grafted quickly and accurately, and then bound with calico and waxed.

Upright stem layering. With upright stem layering, the best results have been obtained with two-year old shoots of stumps or pruned trees. The branch to be layered is ringed and the bare cambium (growing layer of the stem) destroyed by gentle rubbing with the back of a knife. A split bamboo filled with leaf mould is placed round the cut. After about nine months the layering should have rooted and then can be severed from the parent tree, and topped for planting out. Shading is necessary for a year after transplanting.



MONGOLIA
Kalgan
Peking
Tientsin
KOREA
JAPAN
SHAN-TUNG
Huang-Ho
SHAN-SI
KIANG-SU
TIBET
HO-NAN
ANH-WEI
Shanghai
Wuhu
Hangchow
Ningpo
HU-PEH
Hankow
Ichang
Yang-tsi-kiang
MeKong
Salween
SZE-CHUAN
Yang-tsi-Kiang
Kiukiang
CHE-KIANG
Wenchow
HU-NAN
Yo-chow
Bohea Mts.
Santuao
Foochow
Taihoku
FU-KIEN
Amoy
FORMOSA
CHINA
Tsangpo
Himalaya
NEPAL
BHUTAN
Brahmaputra
Patkoi
YUN-NAN
KWANG-SI
Tsi-Kiang
Canton
KWANG-TUNG
Hong Kong
Pacific
Ocean
Ganges
Barak
Lushai
KWEI-CHOW
Meng-tze
Songkoi
TONG-KING
INDIA
Calcutta
Chittagong
Arakan
BURMA
Shans
HAI-NAN
South
China Sea
PHILIPPINE ISLANDS
Irawadi
Salween
LAOS
SIAM
Menam
MeKong
ANNAM
Bay of
Bengal
CAMBODIA
SKETCH MAP
of
SOUTH-EAST ASIA
including the
Tea Districts of China and
Natural Tea Tracts
Scale — 1 inch = 350 miles
land above 12,000 feet
" 3,000 to 12,000 feet
" below 3,000 feet

CHAPTER II

CLIMATE AND THE PRODUCTION OF TEA

The distribution of tea areas—The effect of climate on tea growth and quality—The monsoon—The climates of North-East India and China—The climates of Japan, Formosa, Ceylon and South India—The climate of the East Indies—The climates of the African tea areas—Climatic conditions in the Caucasus and North India.

BEFORE opening up new tea lands three primary factors must be considered, the first of which is the suitability of the climate. The other two factors are the availability of plenty of cheap labour and a market for the commodity when produced. The problems presented by the last two were acute thirty years ago when India, Ceylon and Java exported a total of about 400 million lb. tea annually. To-day, when the export figure is about 800 million lb., they are still more acute but, in spite of these difficulties, new countries are still embarking on the tea venture. Projects are going forward in Kenya and Uganda, and attempts to produce tea commercially in Indo-China and the tropical parts of the Americas are being considered. These new areas will largely create and supply a local demand for tea.

THE DISTRIBUTION OF TEA AREAS

Tea is grown over a wide range of latitude. The most northerly tea area is in Georgia, situated in the Trans-Caucasian province of the U.S.S.R. The tea districts are near the Black Sea, about latitude 42° N., where the winter is long and severe, and 10° of frost is sometimes registered and snow is common.

The most southern tea area is in Natal, about latitude 30° S. Here the climate is equable and mild, though

neither hot nor moist enough for vigorous growth. The average minimum temperature in the coldest month is 52° F.

Between the two latitudes mentioned tea is cultivated in a very large number of countries. The chief areas, in order of the size of the crop produced, are the Yang-tsi Valley and south-east China, North-East India, Ceylon, Java, Japan, South India, Sumatra and Formosa.

In North India, tea is grown in the Kangra Valley, Dehra Dun and Ranchi. Tea has been long established in the Caspian province of Persia. Tea is produced in Natal, Southern Rhodesia, Nyasaland and Kenya. Tea estates have been opened in Burma and the Malay States, whilst in French Indo-China the Government is encouraging the production of tea. Tea for local consumption is grown in Fiji, Mauritius and the Azores.

Tea can be grown in South Carolina, U.S.A., and many years ago an experimental station was established there. China tea was grown in the botanical gardens near St. Sebastian in Brazil about a hundred years ago, and tea as a commercial proposition in Brazil is now being considered.

Vast areas of land eminently fitted for tea are still available in or near the present tea growing countries. In the Netherlands East Indies and Indo-China there are almost limitless tracts awaiting development. Large areas in South India and British Malaya can be opened out. In Assam, the country at the head of the Brahmaputra Valley, at present under virgin jungle and largely occupied by the Sadiya Frontier Tract, could furnish sufficient acreage to yield an annual crop at least equal to that at present exported by the whole of the Assam Valley.

In spite of the fact that such large areas of suitable tea country can be had, mistakes in the choice of location are frequently made. Even in the Brahmaputra Valley, in

many parts the country *par excellence* for tea, the opening of fresh land in certain areas involves some risk, quite apart from such considerations as soil and drainage. Over a distance of a hundred miles in Assam the rainfall may show a steady decrease from 100 to 50 inches per annum. Tea planted at one end of this line is a success, and at the other end a commercial failure. The study of climate and the production of tea is still therefore a matter of more than academic interest.

The Effect of Climate on Tea Growth and Quality

Tea will grow almost anywhere where it is wet and warm, but not many climates will enable it to be grown with profit. Generally speaking, an estate, European owned and managed, can only thrive where growing conditions approach the ideal so that big crops can be gathered. Exceptions to this are seen in Darjeeling and some high-grown areas of Ceylon, where the quality of the tea made compensates for the small crop.

A vivid description of climatic conditions which will ensure heavy crops is given in the following extract.[6]

'To describe the best tea climate in two words, we point confidently to Eastern Bengal. Indeed the judgement of a considerable portion of the Indian public interested in tea has long since pronounced the same decision. A hot moist climate, where the thermometer in the shade never exceeds 95° F., never falls below 55° F., where the rainfall yearly aggregates 100 to 130 inches, where there is never any long drought, but where rain falls at reasonable intervals all the year round, where heavy dews are frequent, where morning fogs are not uncommon, where the sun shines hot in an atmosphere perfectly free from dust, where at no season can a breath

[6] *Tea Cyclopædia*, Calcutta (1881), 91.

of hot wind be felt, where light penetrating rain is more common than furious downpours, where the effect of the entire climate is essentially enervating to man and takes much out of him, these in our opinion are the conditions that make a good tea climate and where it is wise, if anywhere, to make tea gardens. Fever and tea go together. It may be a painful fact for tea planters, but it is no less true. No highly successful tea district can ever be a healthy one.'

Eastern Bengal refers to what nowadays constitutes the province of Assam. Fortunately the statement that tea and fever necessarily go together no longer holds good.

In North-East India during the heaviest cropping months the average maximum and minimum temperatures are about 90° and 78° F. respectively, and the relative humidity at 8 a.m. is between 90 and 100 per cent. The vapour pressure in these months is about 0·9 to 1·0 inches of mercury. Under such climatic conditions the tea produced is generally poor in quality, and the liquors lack flavour and strength.

With lower temperatures and humidities, the rate of growth of the leaf is slower and then quality and flavour may appear. In North-East India the quality periods are in the spring and autumn.

In Ceylon quality occurs during the drier parts of the year, and is most marked in the higher altitudes where temperatures are comparatively low. The same holds in Java. In China, the finest quality Anh-wei teas come from the slopes of mountains 3,000 feet high, and the best Hsienya teas come from still greater heights in the Kiang-si mountains.

Conditions producing slow growth do not necessarily ensure quality teas, for other factors, some known, like the soil, and others unknown, also influence quality.

The climate of some of the African tea areas makes for slow growth, but the teas so far produced in some of the districts show little sign of marked quality.

As described in the previous chapter, there are two main tea forms, the China and India. The leaves of the China varieties are small and thick, and so designed that they are able to withstand cold and drought, but they also thrive in hot, humid climates. On the other hand the India varieties have thin, large leaves, equipped for rapid transpiration and growth in a hot, humid atmosphere, but they do not do well in the colder and dryer districts.

Assam plants make little headway in Japan, where although the climate is moist it is cold in the winter. In the hot, dry spring of Ranchi the Assam plant fails entirely, but the China plant is able to exist, although the spring flush may wilt, and the young shoots die back. In the Caucasus, the Assam varieties are often blackened by the frost whereas the China varieties are apparently unaffected.

Thus the China varieties are able to withstand a much greater range of climatic conditions than the Assam or India varieties.

In Darjeeling and the high-grown areas of Ceylon the China and China hybrid varieties are generally planted. In Darjeeling it has been found that although the Assam plant does well, the teas produced do not show the same quality as those made from China bushes.

The China varieties thrive in the plains of North-East India and were planted there originally in preference to the indigenous plant. The China plants have now been practically all abandoned or uprooted and replaced by Assam varieties. These are not only easier to pluck and are better yielders, but give better quality teas when grown in the plains than do the China varieties. The

experience in Java with China varieties has been the same as in North-East India.

It is doubtful whether the Assam varieties would do well in the Yang-tsi Valley of China, but in parts of south-east China they should thrive and yield well. Assam varieties are already being planted in Formosa, and it is probably only a matter of time before extensive areas of the large leaved plants are put out both in this country and in south-east China.

The Monsoon

In order to appreciate the seasonal changes in the climate of most of the tea countries, some knowledge of the climatic phenomenon known as the monsoon is necessary. The term is derived from the Arabic, *mausim*, literally meaning season. The monsoon dominates the climates of India and China, and affects profoundly those of Japan, Formosa, Ceylon and South India. The African tea countries and the tea area in the Caucasus are also influenced by the monsoon. The Netherlands East Indies contain the only large tea area not affected by monsoon changes.

Briefly put, the effects of the monsoon on world climatic conditions are as follows. Between the latitudes 15° and 35° both north and south of the Equator, two belts of arid regions encircle the world. In the northern hemisphere these regions include the Sahara desert, Egypt, the Syrian and Arabian deserts, most of Persia and the Thar desert of northern India. But for the wet monsoon, north India and much of south China would be arid or semi-arid regions.

Over a great part of the globe certain air movements generally prevail for most of the year. Between the equatorial belt and the north and south temperate zones are two belts of high atmospheric pressure from which

air flows both to the Equator and towards the poles. This air drift arrives at the Equator from the north-east and the south-east, and these two sets of air currents are known as the trade winds. They are moist and bring rainfall to the tropics.

In the north temperate zone the air from the high pressure belt arrives from the south-west or west, and in the south temperate zone from the north-west or west. These winds are called the anti-trades and are moist and mild when they blow off the sea. The British Isles are situated in the track of the south-west anti-trades.

The high pressure regions between the trades and anti-trades are belts of calms and of scanty rainfall, in which the arid regions already mentioned are located.

This world system of air currents is disturbed over the land mass of Asia by the air movements which occur over the central Asiatic plateau. This area includes Tibet and Mongolia and lies approximately between latitudes 30° and 50° N.

During the northern winter central Asia is exceedingly cold, and becomes a region of high atmospheric pressure. The anti-cyclone which thus forms causes air to flow in all directions from the plateau to the coast of Asia from Siberia, by Japan, China and India, to Arabia. Coming from the desert this air is dry, and accordingly China and north India experience their dry, cold weather at this time. Before it reaches Japan, Formosa, Ceylon and South India, the wind crosses the sea where it picks up moisture, and arrives wet and cold in Japan and wet and cool in the other countries mentioned.

During the northern winter the normal trade winds are impinging on the east coast of Africa, bringing rain to the stretch from the Equator to Durban. The normal anti-trade air drift is at this time moving across the

Black Sea to the Caucasus, bringing rain to the tea district there.

As the summer advances in the northern hemisphere, the central Asiatic plateau becomes exceedingly hot and gradually changes from an area of high to one of low atmospheric pressure. As this change proceeds, the outward air flow, blowing across India and China to the sea, is first weakened and then extinguished, till finally the direction of the air movement is completely reversed. The air drift is then towards central Asia from all points of the compass. Coming across the warm Pacific and Indian Oceans this wind is laden with moisture, and so the wet monsoon arrives. In India the term monsoon is used colloquially to denote only the wet season.

Not only are north India and China affected by the wet monsoon. In Japan, Formosa, Ceylon and South India the reversal of the wind direction brings an increase in rain to those parts which face the monsoon current.

The east coast of Africa is affected by the summer depression over central Asia, and the trade winds blowing to that coast are thereby weakened. As a result the rainfall is reduced and a dry season follows.

In the Black Sea the attraction to central Asia is felt and there is accordingly an air drift towards the east in the summer months. This current, like the south-west anti-trade blowing in the winter, crosses the sea and brings rain.

The Climates of North-East India and China

Tea is grown in North-East India between latitudes 23° and 28° N. and in China mainly between 23° and 31° N. The climates of the tea districts in these two areas are considered together for several reasons. Both are included in what may be determined the natural tea

tract, both have the true monsoon climate, and they are the two largest tea producing areas in the world.

India, hemmed in by high mountains and the objective of the air circulation of a whole ocean, has a much more marked change in seasons than China, which is open to central Asia by way of Mongolia.

In north India, the period just before the rains break is one of intense heat and dryness, and when the monsoon arrives with dramatic suddenness in the middle of June, conditions change in a few days from those of the desert to humid tropics. The tea districts of North-East India are not subjected before the rains to the same hot, dry conditions that hold in northern India, a fact which makes tea planting profitable in Assam and parts of Bengal. A fuller description of climatic conditions in North-East India is given elsewhere.

The monsoon in China yields less heavy rainfall than in India, neither is the cold season so dry, and parts of the coast even get rain from the winter monsoon. Winter in the Yang-tsi Valley resembles that in Great Britain, but is much shorter. Winter in Canton is like the English summer, although snow has been known to fall there. South-east China, ridged more or less at right angles to the wet monsoon current, receives more rain than the plateau to the south-west of China. Thus in the south-east the rainfall averages about 60 inches, in Sze-chuan about 40 and in Yun-nan about 38.

Meteorological data of the actual tea areas in China are difficult to obtain. The table below shows the rainfall in three indicative centres in China and at Tocklai, in Middle Assam. This last station does not represent average conditions in North-East India, where the rainfall shows wide variation, but the figures shown indicate the marked difference between the wet and dry seasons.

Table showing Average Rainfall in Middle Assam and China

	Tocklai	Canton	Shanghai	Hankow
	in.	in.	in.	in.
January	0·9	1·4	2·2	2·1
February	1·5	3·5	2·3	1·1
March	3·4	7·0	3·4	2·8
April	7·8	8·3	3·8	4·8
May	9·1	10·9	3·7	5·0
June	13·5	9·9	6·5	7·0
July	16·1	11·0	5·5	8·6
August	13·2	9·7	5·9	4·6
September	11·3	5·7	4·7	2·2
October	4·9	3·5	3·2	3·9
November	1·0	1·0	1·7	1·1
December	0·3	1·0	1·2	0·6
Total	83·0	72·9	44·1	43·8

The next table gives the monthly average maximum and minimum temperatures for the same stations. Those for Tocklai are fairly indicative of the temperatures recorded over the whole of the tea area of North-East India. In the cold weather the minimum temperatures are a few degrees higher in the Surma Valley and the Dooars than in the Brahmaputra Valley.

The latitude of Tocklai is 27° N., that of Canton 23° N., whilst that of both Shanghai and Hankow is 31° N. It will be noticed that the winter in the Yang-tsi Valley is much more severe than in Assam.

The Climates of Japan, Formosa, Ceylon and South India

These four tea countries are distributed over a wide range of latitude and accordingly their climates show considerable differences regarding temperatures. They

Table showing Average Temperatures in Middle Assam and China

	Tocklai		Canton		Shanghai		Hankow	
	max. °F	min.	max. °F.	min.	max. °F.	min.	max. °F.	min.
January	70	59	65	54	46	33	47	33
February	73	53	62	53	47	34	49	37
March	79	60	68	59	55	40	58	44
April	83	67	77	68	66	50	69	55
May	86	72	84	75	77	59	80	64
June	89	76	86	78	82	67	86	72
July	90	78	88	80	90	74	90	77
August	89	78	89	80	90	74	92	78
September	88	76	88	78	82	66	83	66
October	85	71	83	73	74	57	73	59
November	78	60	75	64	63	45	61	47
December	72	51	69.	57	53	36	50	37

are all, however, very definitely influenced by the monsoon, although their monsoons differ essentially from those of China and North-East India in that the air currents both inwards to and outwards from the central Asiatic plateau are moist and bear rain. The reason for this so far as Japan, Formosa and Ceylon are concerned, is that these countries are separated from the Asiatic continent by the sea.

In the case of South India, the north-east monsoon, although dry when it leaves north India, picks up moisture in crossing the Bay of Bengal and deposits rain on the Madras coast. The south-west monsoon spends most of its force in South India on the west or Malabar coast, and the tea districts on this side of peninsular India receive torrential rain from this source in June, July and August. The rainfall in the Anamalais illustrates this

last point. The Nilgiris receive rain from both monsoons but most from the north-east.

The following table shows the average monthly rainfall at Kanaya in Japan, at Haichin in Formosa, and at two locations in Ceylon and two in South India. In Ceylon, Kandy receives rain from both the south-west and north-east monsoons, while Badulla receives most from the north-east and very little from the other monsoon.

Table showing Average Rainfall in Tea Districts of Japan, Formosa, Ceylon and South India

	Kanaya	Haichin	Kandy	Badulla	Anamalais	Nilgiris
	in.	in.	in.	in.	in.	in.
January	2·8	3·7	5·2	9·7	0·4	2·4
February	5·5	7·8	2·2	3·0	0·1	2·3
March	7·5	9·5	3·9	4·3	0·2	1·9
April	11·0	10·3	6·8	7·5	3·5	4·1
May	9·0	13·4	5·4	4·5	4·0	6·0
June	11·0	14·8	9·6	2·3	28·6	4·1
July	8·2	5·9	7·5	2·0	83·2	4·7
August	12·3	10·4	5·7	3·2	23·7	4·3
September	15·2	9·1	5·9	3·4	17·3	6·6
October	7·8	4·0	11·8	9·9	8·2	14·4
November	7·1	2·5	10·6	10·5	3·4	10·2
December	3·0	3·9	9·1	12·4	0·3	4·3
Total	100·4	95·3	81·7	72·7	172·9	65·3

As indicated above, the temperatures in the four countries under discussion are very dissimilar. The Japan tea districts are situated about latitude 35° N., those of Formosa about 25° N., those of South India about 12° N., and those of Ceylon about 6° N. In Japan and Formosa very marked seasonal differences in

temperature are observed. In South India a less marked but still definite change is registered as is shown by the monthly average temperatures at Coimbatore given later. This place is situated in the Palghat gap, between the Nilgiri and Cardamom Hills, and although the temperatures in the hills where much of the tea is grown are lower, the seasonal differences are of the same order as in Coimbatore.

In Ceylon the monthly mean temperature does not show any wide seasonal change. At Ratnapura in the lowlands it varies from 79° to 82° F. At Kandy, altitude 1,474 feet, it varies from 74° to 79° F., at Badulla, altitude 2,225 feet, from 70° to 76° F., and at Nuwara Eliya, altitude 6,188 feet, from 57° to 62° F.

The next table shows average maximum and minimum temperatures at Kanaya, Haichin and Coimbatore.

Table showing Average Temperatures at Kanaya, Haichin and Coimbatore

	Kanaya		Haichin		Coimbatore	
	max. °F.	min.	max. °F.	min.	max. °F.	min.
January	48	34	66	51	87	64
February	51	35	64	51	92	66
March	56	38	66	55	96	70
April	65	49	73	63	97	73
May	71	54	82	68	95	74
June	75	62	85	73	90	72
July	82	70	90	75	88	71
August	85	71	90	74	88	71
September	79	66	86	71	89	71
October	71	56	82	65	81	71
November	63	48	77	60	86	69
December	53	36	70	55	85	66

The Climate of the East Indies

The East Indies, in which are included Java, Sumatra and British Malaya, lie outside the monsoon area and have what is termed an equatorial climate. The temperature is moderately high all the year round and the monthly mean shows small variation. The difference between the night and day temperatures is small, usually between 10° and 15° F. In many respects the climate of the Ceylon tea districts resembles that of Java and Sumatra, although the last two countries are not subject to the very definite changes of wind direction associated with the monsoon.

The difference between the January and July mean temperatures at certain places in the tea districts of Java and Sumatra is shown below. The altitude of each station is given and, for comparison, figures for stations in Malaya, Ceylon, Assam and China are included.

	January mean	July mean
	°F.	°F.
Buitenzorg, Java (885 ft.)	75	77
Bandoeng, Java (2,000 ft.)	72	72
Pengalengan Plateau, Java (5,000 ft).	62	62
Siantar, Sumatra (1,500 ft.)	71	73
Cameron Highlands, F.M.S. (4,750 ft.)	63	64
Kuala Lumpur, F.M.S. (400 ft.)	79	80
Kandy (1,654 ft.)	73	75
Nuwara Eliya (6,188 ft.)	57	59
Tocklai (290 ft.)	60	83
Hankow (300 ft.)	40	84

Frosts occur on the Pengalengan plateau and may be registered from July to October. In the lowest basins of this undulating area damage is done to tea when the temperature falls below 30° F. The higher parts escape the worst of the frost.

Although the Dutch Islands are subject to a change in wind direction from April onwards as the thermal equator moves north, and another from November as the Australian continent warms up, the breeze is always a moist one. The strength of the wind is not great and is liable at all times to variation in direction.

In these areas the sun usually rises in a clear sky, or perhaps a few stratus clouds, little more than a morning mist, are present. About nine o'clock cumulus clouds form and increase till rain comes with tropical force in the afternoon, after which a clear, calm night follows.

Most of the rain in Java comes from the north-west, for this breeze has travelled far over the ocean, and the west of Java is wetter than the east. The east wind has travelled less far over water and brings less rain. East Java

Table showing Average Rainfall in Java, Sumatra and British Malaya

	Soeka-boemi	Penga-lengan	Siantar	Cameron Highlands	Serdang
	in.	in.	in.	in.	in.
January	24·7	13·9	11·1	9·4	6·2
February	11·2	12·5	7·2	5·8	5·4
March	15·1	13·2	8·9	8·1	9·2
April	16·1	10·9	8·7	13·4	11·2
May	10·4	6·6	12·0	8·7	7·8
June	6·5	4·4	6·7	6·4	4·6
July	3·9	2·4	6·7	4·7	4·2
August	3·8	2·6	9·6	4·9	3·4
September	4·0	4·2	13·7	12·5	6·1
October	9·1	7·7	16·7	14·3	12·7
November	13·8	10·7	8·8	15·2	11·8
December	16·4	13·3	9·8	13·0	9·2
Total	135·0	102·4	119·9	116·4	91·8

is thus liable to a comparative drought, and partly on this account tea is confined to the other end of the island.

The table on page 35 shows the average monthly rainfall at Soekaboemi and on the Pengalengan Plateau in Java, at Siantar in Sumatra, and on the Cameron Highlands and at Serdang, on the coastal plain, in British Malaya. These last two are centres where attempts are being made to develop the tea industry.

THE CLIMATES OF THE AFRICAN TEA AREAS

Before giving details of the climates of the African tea areas some mention may be made of the development of the industry in this continent, since the matter is not discussed elsewhere.

The commercial production of tea in Natal dates from 1878, when plants were imported from Assam, although experimental plants were placed in the botanical gardens in Durban in 1851. Only about 2,000 acres are at present under tea in Natal, and most of the product is consumed locally. The industry is not expanding, partly because of labour difficulties.

In Nyasaland missionaries attempted to establish tea plantations at Blantyre in 1887. Commercial production began in 1900 and now the principal areas are at Mlanji and Cholo. About 8,900 acres are planted and the tea exported all goes to England.

Tanganyika and Kenya are most recent ventures. In the former territory the area is scattered, and in 1930 about 1,100 acres were planted. In Kenya the area in the same year was about 9,000 acres, and very large grants have been acquired for future development. The tea is being planted out in the Kericho district where the rainfall is well distributed and much greater than in most other parts of Kenya. At Nairobi, for example, the annual precipitation averages only 37 inches.

Tea is being grown successfully near Umtali in Southern Rhodesia, and although the rainfall is short the bushes are said to stand the drought well and to have made growth almost equal to that in Assam during an equal period. A crop of not more than 500 lb. tea per acre is expected, a yield considerably less than in Assam, where 800 lb. is common.

The African tea areas stretch from the Equator to 30° S. and are located on the eastern side of the continent which is served by the trade winds. During the southern summer, when the thermal equator shifts south, the trades blow steadily to the east coast of Africa bringing rain in fair quantity, especially to Natal, Rhodesia and Nyasaland. As the summer advances in the northern hemisphere the rain belt moves north, leaving the areas south of Nyasaland short of rain, but bringing good falls to

Table showing Rainfall in African Tea Areas

	Durban	Umtali	Zomba	Kericho
	in.	in.	in.	in.
January	4·7	7·6	11·3	3·2
February	4·7	6·3	11·0	5·3
March	4·5	4·7	8·5	6·3
April	2·5	0·9	3·8	9·7
May	1·8	0·5	0·7	11·7
June	0·9	0·2	0·4	8·3
July	1·5	0·2	0·3	5·5
August	2·1	0·2	0·1	7·1
September	2·8	0·4	0·3	6·4
October	4·1	1·2	1·7	5·7
November	5·3	4·0	5·4	4·5
December	4·5	4·8	10·7	2·2
Total	39·4	31·0	54·2	75·9

Kenya. Later, the low pressure system over central Asia makes itself felt, and the air drift towards the African coast is weakened. The rainfall in Kericho is thereby reduced and in other parts of Kenya, e.g. Nairobi, almost ceases till October. These changes are illustrated in the rainfall table on page 37. Zomba is in Nyasaland.

All the African tea areas, except Kericho which lies near the Equator, show considerable variation between summer and winter temperatures. Owing to the altitude of Umtali (3,730 feet), Zomba (3,138 feet) and Kericho, Lumbwa Mission (6,990 feet), the air temperatures in these places are below those of Durban, which is at sea level. The sun temperature or solar radiation, as measured by a black bulb thermometer, increases from Durban to Kericho, independently of air temperature or altitude.

The following table shows the average maximum and minimum monthly temperatures for the four stations

Table showing Temperatures in African Tea Areas

	Durban		Umtali		Zomba		Kericho	
	max. °F.	min.	max. °F.	min.	max. °F.	min.	max. °F.	min.
January	85	68	83	63	82	65	82	49
February	84	68	81	62	80	65	85	52
March	85	69	80	60	80	64	80	49
April	79	60	79	57	78	60	78	49
May	76	47	76	53	75	57	78	48
June	76	54	73	48	74	54	79	49
July	75	52	73	47	72	52	77	47
August	77	57	75	50	76	54	79	46
September	74	58	79	54	82	59	80	47
October	76	62	84	58	87	64	79	49
November	81	65	83	61	87	65	78	50
December	81	64	83	62	83	65	77	51

under discussion. The latitude of Durban is 30° S., of Umtali 19° S., of Zomba 15° S. and of Kericho 2° S.

Climatic conditions are generally too dry and not hot enough for the vigorous flushing obtained in the plains of India. Unfortunately the quality of the teas produced in some of the African districts shows no marked promise, so far, of compensating for the smallness of the crop. The Kenya teas, however, although made from recently planted bushes, often show attractive flavour and quality.

Climatic Conditions in the Caucasus and North India

In discussing the general question of climate and its relation to tea growth, something must be said regarding limit conditions beyond which the tea plant will not grow. Tea will neither tolerate extreme cold nor extreme drought, although the degree of toleration varies with the type of bush.

A tea area where climatic conditions are not far removed from the extreme limit of cold tolerated by tea is that of western Georgia in Trans-Caucasia. Some consideration of the climate in this country is of interest in view of the intention of the U.S.S.R. rapidly to extend tea production there. In a few years' time it is planned to have under tea an area of 250,000 acres, producing 100 million lb. annually. The country which is being opened out is a triangular area open to the Black Sea on the west and enclosed on the other two sides by mountains. The latter shut off most of the cold winds from the Russian plains and also ensure plentiful rainfall.

Rain falls in Georgia throughout the year. The winters are wet on account of the rain brought by the south-west anti-trade wind blowing across the Black Sea. In the summer the Caucasus comes under the influence of the low pressure system which has developed in central Asia, and the air drift is accordingly still across the Black

Sea, but from the west instead of the south-west. This summer breeze, like that of the winter, is a moist one bringing rain.

The table shows the average monthly rainfall at Chakwa, one of the tea centres, and the rainfall and temperatures at Poti, a place situated on the coast north of Batum. In the tea areas other than Chakwa the rain distribution is not so good and drought in April and May is common. Much of the winter precipitation is as snow.

Table showing Rainfall and Temperatures in West Georgia

	Chakwa Rainfall	Poti Rainfall	Poti Temperatures, °F.	
	in.	in.	max.	min.
January	10·0	5·2	59	29
February	6·8	4·3	59	28
March	5·8	3·2	71	30
April	5·8	3·2	78	41
May	4·6	2·3	82	50
June	7·4	6·0	86	59
July	7·1	6·0	86	64
August	9·3	9·5	88	68
September	10·7	9·0	82	55
October	12·1	5·8	81	50
November	10·7	4·6	72	40
December	9·8	6·0	64	32
Total	100·1	65·1		

Although the rainfall is sufficient and well distributed the temperatures are not really satisfactory, and the months from November to March are much colder than is desirable for tea cultivation. Even near the coast where the mildest climate occurs, the minimum temperature in these months may touch 22° F., and cause serious damage to the more delicate Assam varieties of tea. In

other parts temperatures may be even lower, and there are records as low as 10° F. The coldest month is February and this has an important bearing on the way winter work on the garden is carried out.[7]

Although the climate of Georgia may be unsuitable for tea development in the manner followed in India, Ceylon and Java, it will apparently allow of an industry run by small farmer owners.

Turning now to the other extreme in climate, the hot and dry, Ranchi and Dehra Dun in north India present interesting cases which indicate fairly definitely the upper limits of heat and dryness tolerated by tea. In Ranchi high temperatures and low humidities are common in April before the monsoon develops. During this period the moist air which drifts into North-East India from the Bay of Bengal bringing cooling showers, misses the Chota Nagpur plateau on which Ranchi is situated.

Tea was first planted in Ranchi in 1862 when the Plateau was forest covered. With the development of the coal fields of the Damuda Valley a need for pit-props was created and the forests were cut down. Deforestation has no appreciable influence on the rainfall as is shown by the records of Ranchi and elsewhere, but there is evidence that since the forests have been removed the humidity of the air has decreased. In the month of May, relative humidities during the daytime as low as 20 per cent are often recorded which, in combination with temperatures in the neighbourhood of 110° F., cause the young leaf constituting the spring flush to die back completely. Only plants of the China varieties can live in Ranchi.

To-day new tea cannot be planted except under dense shade like that of the mango tree, or under a complete

[7] H. H. Mann, 'The Recent Tea Developments in Georgia,' *Ind. Tea Assn. Quar. Jour.*, Calcutta (1932) pt. 2.

covering of semi-permanent green crop. The care needed to bring new plants into bearing is so great that planting is not now a commercial proposition, and it is likely that tea in Ranchi will gradually disappear.

In Dehra Dun conditions are not quite so severe, for the narrow *dun* or valley, which is situated between the Siwalik Hills and the Himalayas, is protected from the scorching winds crossing the Gangetic plain before the break of the monsoon. With careful attention to shading new plants can be reared and although most of the tea is of the China variety, Burma plants can be made to grow.

The following table shows climatic conditions so far as rainfall and temperatures are concerned in these two districts of north India.

Table showing Rainfall and Temperatures in Ranchi and Dehra Dun

	Ranchi			Dehra Dun		
	Rainfall in.	max. °F.	min. °F.	Rainfall in.	max. °F.	min. °F.
January	0·6	74	51	2·2	66	45
February	1·2	77	55	2·5	69	47
March	1·1	87	64	1·5	80	55
April	0·8	96	72	0·8	91	64
May	2·3	99	76	1·6	95	71
June	9·0	92	76	8·3	93	74
July	14·5	84	73	24·3	86	74
August	13·6	84	73	25·7	84	73
September	8·2	84	72	9·3	84	70
October	2·8	83	66	0·3	82	61
November	0·4	78	58	0·9	75	52
December	0·2	73	51	0·7	69	46
Total	54·7			78·1		

CHAPTER III

TEA SOILS

The physical characteristics of tea soils—The classification of tea soils—The acidity of tea soils—The chemical properties of tea soils—The influence of the soil on quality and crop.

THE PHYSICAL CHARACTERISTICS OF TEA SOILS

THE tea plant will thrive on soil of practically any texture. In North-East India successful tea soils range from the lightest of sands to the stiffest of clays, and include silts and loams of all types, whilst in Cachar tea grows vigorously on peat soils (*bheels*) which have been drained. Tea can be grown on stony soils and in rocky places.

Land which has recently carried jungle is best suited for tea, because it is usually rich in plant food and in good tilth. Grass land and land which has been grazed may also give big tea crops although in such cases more work must be put into the soil than when forest land is planted.

Tea will not grow in swamps and if planted on badly drained land the bush becomes sickly and yields poorly. Even a few days of water-logging has the effect of turning the leaves of the bush yellow.

In tea countries where a marked dry season is experienced, as in North-East India, it is essential that the bush be deeply rooted in order to withstand the drought. The depth of the roots is largely determined by the height of the soil water table in the wet season. When this is near the surface the roots are shallow and, in such cases, if the water table recedes far in the dry weather the roots may lose contact with moist soil and the bush suffer from

drought. Under these conditions drainage is essential, primarily with the object of lowering the water table in the wet season in order that the roots may penetrate into the soil.

In the light sands which are common in parts of Assam, the water table may move over a wide range making deep drainage very necessary. With the heavier soils this is not the case and drainage, if any, is undertaken with the object not of lowering the height of the water table but of carrying off surface water. Such an object is achieved by shallow drains.

The sub-soil is important in that it affects drainage and root development. A soil pan or a stiff sub-soil may restrict root growth and aggravate the effect of the drought, if there is one.

The geological origin of the soil is not important, provided the latter has had time to weather and thus lose excessive lime by leaching. Tea will not grow well on limestone soils or on soils which have recently been flooded with alkaline water. This point is one of chemical interest which will be dealt with later.

The tea areas of the world are located in places of widely different geological formations. In North-East India most of the tea soils are Quaternary and recent alluviums, and the rest are mainly soils formed *in situ* from gneisses and Tertiary sandstones. In South India and Ceylon much of the tea is put out on soils resulting from the weathering of Archaean rocks. The soils of Java consist of the products of eruptive rocks, and most of the tea soils are derived from the weathering of volcanic ash, sand and lava of the Tertiary period.

Although tea can be grown on almost any class of soil, it does best on a medium or light loam. Like most other plants it prefers a deep, friable soil well supplied with plant food, but it will grow on poor soils and in

China and Japan it is often relegated to hillsides where other crops cannot be made to pay.

The climate may be a factor in deciding the suitability or otherwise of a soil for tea. In Assam, in areas where the drought is severe, tea planted on very light soils may fail. This is especially the case if during the early years, before the bushes are well established, the spring droughts are more prolonged than usual. Again some of the stiffest of the yellow, sticky clays in Assam are workable because the effect of the fierce sun in the dry season is to put tilth into such soils. If there were no marked drought it would be almost impossible to work some of these clays.

The Classification of Tea Soils

The general classification of soils is admittedly a difficult task. Classification on a purely physical basis, dividing soils into sands, silts, loams, etc. is not satisfactory, for it may involve the grouping together of soils otherwise absolutely unrelated, although such a classification is of value when dealing with related soils over a limited area.

A classification based on geological origin is also unsatisfactory and will not serve because the influence of the geological factor is often far outweighed by the climatic one. For example, in parts of India it is impossible to distinguish a laterite formed from an underlying alluvium and one formed from a gneiss or a slate. In such instances the climate has eliminated the original geological differences.

It is climate which is the main factor in ultimately determining a soil. Many soils are still characterized by the rocks which gave rise to them but, given time, the constant working of a definite set of climatic conditions tends to produce a similar product however much

the original materials may differ. The study and classification of soils from this angle was developed mainly by Russian scientists, and the system of classification which they have worked out is manifest clearly in Russia and Siberia where climatic influences far outweigh those of geology. In these areas the soil belts run across the country from east to west following climatic belts.

In order to predict whether tea soils as a group may fall within one of the types contained in the Russian system of classification, it is necessary first to consider whether the climates in tea areas show any common characteristics. This they do, for in order to grow tea successfully at least a part of the year must be hot and humid. Such conditions produce very definite soil changes which are collectively termed laterization, a process which will now be described briefly.

Under moist conditions, with an average temperature above about 59° F., the humic acid formed from the organic matter in the soil is rapidly oxidized. The soil water then takes up bases like lime and magnesia and, at the same time, some of the silica in the soil is detached from its combination with alumina. As the soil water passes through the soil, bases and silica are thus leached out, and the soil remaining becomes rich in free alumina. At the same time the percentage of iron in the soil proportionately increases as the other substances are removed, and since the iron is present largely as the red oxide the soil becomes redder as the changes described proceed.

These changes may be assumed to be taking place in all tea soils at some part of the year.

In some tea countries the hot, wet season is followed by a cold, wet one, as in Japan, the Yang-tsi Valley of China and in Georgia. Under cool, wet conditions a

different set of soil changes is observed. With an average temperature below about 59° F., the humic acid as it is formed in the soil is not oxidized, but dissolves iron and alumina from the soil, which substances are washed through. As a result there is a bleached layer of soil just below the humus layer, and below that may again be found the oxides of iron and alumina which have been washed from above. This process is known as podsolization and the type of soil thus formed is called a podsol. The characteristic of such soils is that they are poor in iron and alumina and rich in bases and silica.

Thus in some tea countries laterization and podsolization proceed alternately, the former in summer and the latter in winter. Whether a soil ultimately becomes a podsol or a laterite depends on the degree to which each process is developed.

A third type of tea climate must now be considered, viz. that of north and north-east India. Here, in the rains, the disintegration of the soil makes for rapid laterization. In the cool, dry season which follows, the water movement in the soil is largely upwards and with it is carried back to the surface some of the silica which was washed down during laterization. The lateritic soil thus tends to become what is known as a red earth, a type common in semi-arid regions. How far the soils in north and north-east India have proceeded towards laterization, and how far the formation of red earth has advanced, has not yet been determined.

In Java several types of soil are met. In the hot lowlands, where rainfall is persistent and the general water movement is downward, typical red laterite occurs. In the higher altitudes where lower temperatures prevail, less well developed types are formed, whilst in the highest mountains there is a layer of bleached, decomposing rock under the humus, indicating

podsolization. In other parts of Java, where percolation through and evaporation from the soil occur alternately with the change of season, black and brownish soils occur.

These last conditions are similar to those in the plains of North-East India. In the hills round the Brahmaputra Valley the bleached layer under the humus is frequently met.

It will be appreciated that there are many stages in laterization, and the exact limits which define a laterite are still under discussion. A measure of the degree to which the process has gone is denoted by the ratio of the silica to the alumina in the clay fraction of the soil. If this ratio is 1·33 or less, then the soil may be definitely termed a laterite. If the ratio is between 1·33 and 2·0 the soil may be classed as lateritic. If the ratio is 2·0 or over, i.e. the silica content of the clay is more than twice that of the alumina, then the soil may be reckoned as non-lateritic.

Taking these ratios as indicative, lateritic soils have been reported in the tea areas of Formosa, Ceylon and Nyasaland. Soils described as lateritic, but without analytical data in support, have been reported from south-east China, the East Indies and North-East India.

Before leaving the subject of laterization it is worth noting that lateritic clays are porous and non-plastic, whereas clays with a high silica-alumina ratio, formed by podsolization under moist, temperate conditions, tend to be sticky and impermeable.

The Acidity of Tea Soils

It has been explained that the process of laterization involves the leaching of bases from the soil. It is therefore not surprising that tea soils are generally poor in lime and that the tea plant prefers a soil with a low lime content, a characteristic which has probably been the

result of natural selection. The most successful tea soils are acid.

The acidity of soils is due mainly to the occurrence of organic acids derived from the decay of organic matter or humus, and to the clay fraction in the soil. In the tropics, where the soil is often poor in organic matter, and high temperatures lead to the oxidization of the humic acid as it is formed, the acidity is mainly due to the clay acid and may be described as 'mineral acidity'.

Soil acidity may be reckoned in two ways. The first, and older way, denotes the amount of lime required to neutralize a given quantity of soil. Since soil acidity is a function of the clay fraction it follows that this measure will vary to some extent as the amount of clay in the soil. The other method of reckoning measures not the amount but the strength of the soil acid, a function practically independent of the amount of clay in the soil.

There are many methods of estimating the lime requirement of a soil which give empirical results of practical value. That adopted in North-East India is the Hopkins method. The details of the method need not be discussed, but it may be stated that on typical, successful tea soils of North-East India the values given by this method follow approximately the size of the clay fraction.

Thus the acidity or lime requirement of a Mal Sand of the Dooars, containing 3 per cent to 5 per cent clay, varies from 60 to 160. This figure denotes the parts of lime to be added to a million parts of soil to make it neutral. A stiff Red Bank soil with a clay content of about 25 per cent may be expected to show a Hopkins acidity of about 800. In judging the suitability of a soil for tea on the Hopkins figure, a knowledge of the clay percentage in the soil is essential, in addition to local knowledge regarding the soil type.

Even with a considerable knowledge of a soil the Hopkins figure is at times misleading and fails to indicate the suitability or otherwise of a soil for tea. On this account a measure of soil acidity which is more discerning is required and has been found in the second method of reckoning mentioned above, which takes count of the strength of the soil acid. The strength of an acid is called its pH value.

The pH value of a soil denotes the concentration of the hydrogen-ion in the soil solution. This ion, if present beyond a certain concentration, produces acidity. Details of the estimation of the pH value are out of place here and it is sufficient to state that a pH of 7 denotes neutrality, that figures above 7 denote alkalinity and below 7 denote acidity. On this scale of reckoning the lower the pH value the less the alkalinity, or the greater the acidity.

Successful tea soils in North-East India usually show pH values between 5·4 and 6. Tea can be made to grow on soils with pH values between 6 and 7, but great care is necessary. The *bheel* soils of Cachar show low pH values and figures round 4 are usual.

In Ceylon, South India and Java, pH values between 6 and 7 are common on good tea soils. In Japan tea soils are only faintly acid. In Nyasaland the acidity of tea soils varies from 5·6 to 6·2, whilst in the Caucasus values of 5 to 5·5 are usual.

It will be observed that the range of soil pH tolerated by tea is a very wide one extending from 4 to neutrality. Yet in North-East India, soils with pH values above 6 do not grow tea well, although the same cannot be said of a soil in Ceylon, for instance. A possible explanation of this apparent anomaly is that a faintly acid soil in North-East India is one rich in available lime, whilst weak acidity in a highly laterized Ceylon soil does not necessitate the presence of much lime. As laterization proceeds

on a young soil the first result will be an increase in acidity as the lime and bases are removed. The second phase will show a decrease in acidity as the clay acid is decomposed in considerable quantities and the soil tends to approach the final product of laterization.

In connexion with the study of soil acidity in North-East India, field experiments have shown that lime has a harmful effect on tea.

Most of the artificial manures in use in North-East India decrease the soil acidity appreciably even when added in normal doses. Sulphate of ammonia, however, very definitely increases acidity, so that by the judicious variation in the type of manure added the soil reaction can be prevented from departing far from the ideal, which under conditions in North-East India is considered to be about pH 5·4.

In some cases in North-East India where the soil is very under-acid sulphur is added. This substance is oxidized in the soil and forms sulphuric acid which dissolves the lime and bases and enables their rapid removal by leaching. Doses of sulphur of 400 to 800 lb. per acre have been used experimentally with good results, but it has also been observed that an equivalent expenditure of money on sulphate of ammonia gives even better results. The effect of the latter is due not only to an increase in soil acidity but also to the plant food supplied.

Many instances of the failure of tea to grow well on faintly acid or alkaline soils are met in North-East India. Thus in areas north of the Brahmaputra, flooded at some time by streams which have come from limestone deposits in the Himalayas, it is often impossible to grow tea of sufficient cropping power to be economical. On this account tea land is nowadays carefully examined for acidity before it is opened up, for there may be no obvious

indication in the natural flora to denote the degree of under-acidity which is sufficient adversely to influence tea.

In many tea gardens weak patches of tea are traceable to the burning of heavy timber during clearing. Wood ashes are alkaline and such patches are usually found to be under-acid.

Old village sites are also infertile for tea, probably for a variety of causes, and all practical attempts to make them fertile usually fail. The addition of sulphur, fertilizers, cattle manure and green crops in reasonable quantities do not enable these soils to carry good tea. Analysis of such soils shows them to be under-acid and generally very rich in phosphates.

The Chemical Properties of Tea Soils

Chemically, tea soils vary widely amongst themselves but as a class they have certain characteristics which distinguish all lateritic soils. The leaching process responsible for the removal of the silica also removes a large proportion of the bases present in the soil, leaving a residue low in plant nutrients compared with soils developed in temperate climates under less intensive conditions of leaching.

In general the available potash and phosphoric acid in tea soils is low. The available potash in Assam may be as low as 0·005 per cent. Some of the Mal Sands in the Dooars, however, show values as high as 0·04 per cent. Compared with other tea soils those of Java show high potash figures, and the use of potash manures in that country is unnecessary. The available phosphoric acid in North-East India is about 0·015 per cent or less. The corresponding figure in Java, Ceylon and Japan is generally lower than this.

The nitrogen deficiency in lateritic soils is not so marked as that of potash and phosphoric acid. In the

poorer tea soils of Assam the total nitrogen may be as low as 0·07 per cent, whilst in the better areas it may be about 0·10 per cent. On the Red Bank in the Dooars the nitrogen may be as high as 0·25 per cent, and on some Cachar *bheels* 0·50 per cent. The best Java soils contain 1 per cent nitrogen, and others average 0·35 per cent. The nitrogen in Japan soils varies from 0·2 per cent to 0·5 per cent, and in Ceylon from 0·09 per cent to 0·4 per cent.

As a result of laterization, the percentage of iron and alumina in the soil tends to increase and the lime to decrease. The table below gives some indicative figures for tea soils.

	China	Ceylon		North-East India	
		Matale	Badulla	Assam	Dooars
	%	%	%	%	%
Loss on ignition	6·58	12·39	8·18	2·87	11·60
Insoluble silicious matter	75·15	56·49	71·12	93·70	68·62
Oxides of iron and aluminium	9·99	19·25	20·41	3·04	17·80
Lime	0·20	0·50	0·20	0·09	0·38

Although the percentage of iron and alumina in the Assam soil is low compared with that in the other soils, it will be noticed that the insoluble silicious matter, which largely represents the inactive part of the soil, is very high in this case.

The Influence of the Soil on Quality and Crop

Before leaving the subject of tea soils a few words may be written about the influence of soil on the quality and quantity of the crop produced. Some observations regarding the effect of manures may also be made, since it might be considered that this will bear some relationship to the question of soil influence.

In China the characteristic flavours which distinguish teas of one district from another are ascribed by Chinese farmers exclusively to the soil. Similar views are held in Japan by tea farmers.

There is no definite scientific evidence in India, Ceylon or Java to show that quality in tea goes with certain chemical or physical properties of the soil. This does not preclude the assumption made by the Chinese, since a soil analysis as at present made is possibly not sufficiently discriminating to detect quality-giving properties.

In discussing the influence of various factors on the quality of tea, the term quality is generally used to denote flavour and character, as opposed to the more easily definable properties such as thickness of liquor, strength, pungency and colour. These last are largely connected with the tannin in the leaf and may be expected to be influenced primarily with the fineness of the leaf plucked. The finer the leaf the greater the tannin content, and there would appear to be no obvious reason why leaf plucked in Cachar, for example, should not make as good liquoring tea as fine leaf plucked in, say, Upper Assam, since in both cases the fresh leaf contains about the same amount of tannin. When fine plucking and careful manufacture have been tried in poor quality areas, good liquors have been obtained, but they are said by tea tasters to lack something, which may be described as quality. Exactly what this is, and what combination of conditions produce it is at present unknown.

The quality of tea is influenced by many factors. Some of these are the variety of the bush, the condition of the bush, the weather, the rate of growth of the leaf, the style of plucking, the fineness of the leaf, the treatment of the leaf in the factory and the method of manufacture. Until all these factors as variables are eliminated the exact influence of soil as a factor in determining

quality cannot be assessed. It is well known that apparently similar bushes, on apparently identical soils, may produce teas differing widely in character and in market value. In such cases the soil and bush as variants are practically eliminated, and an indication of the degree to which other factors may influence the final product is given.

It is generally considered in North-East India that tea growing steadily gives better leaf than that growing in spurts. On this account it is often noticed that gardens on clay soils produce better teas than those on sandy soils in the same district. The rate of growth of the bush is steadier on a clay than on a sand. Here, as with most things connected with tea, notable exceptions can be found.

The effect of manuring on quality may now be considered. General experience in India, backed by some experiments, indicates that heavy doses of nitrogenous manures (more than 60 lb. nitrogen per acre) reduce the quality of the tea and produce teas with thin liquors. There is some indication that phosphatic manures make for quality, whilst potash manures make for pungency in the liquors. The indications are, however, by no means clear and it has not been observed that soils naturally well supplied with any of the three constituents mentioned, produce teas with qualities similar to those which appear to result from the addition of any of these three substances as manures.

The general idea held by practical tea planters is that artificial manures like sulphate of ammonia and nitrate of soda lower the quality of tea, whilst slow acting manures like cakes and meals, do not have this harmful effect. This idea may be well founded, especially in a country like North-East India, where the manure is added about March and has its full first effect on the second flush,

which gives quality teas. It is quite possible that severe disturbance of the natural growth at this period may adversely affect quality.

Whilst too much weight should not be given to vague assertions, it must be recorded that the opinion is held by many planters in Assam that the Green fly effect, in which the early flushes are of stunted growth and produce highly flavoured teas, has steadily decreased during the past few years. This change is often attributed to the stimulus given by artificial manures.

Tea farmers in China usually refrain from manuring bushes which are plucked for black tea manufacture, since they consider that quality is thereby lost. Green tea bushes are manured. In Japan, where only green tea is made, farmers do not favour the use of artificials which they consider lower quality.

The influence of soil on the size of the crop is well known. Soils rich in nitrogen generally give big crops, and additions of nitrogenous manures increase the crop on all soils. In North-East India it has been observed that even *bheel* soils which are already richly supplied with nitrogen, respond to this form of manuring.

Soils rich in either potash or phosphoric acid have not been observed to give big crops on this account. In North-East India the addition of potash or phosphatic manures does not usually produce an economic crop increase, but they are added because it is considered that the application of an unbalanced manure mixture may reduce the quality of the leaf.

PRUNING TEA

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Chapter IV

THE CULTURE AND PREPARATION OF TEA

The planting of tea—Pruning and the formation of the tea bush—Plucking—Cultivation and manuring—The pests and blights of tea—The preparation of tea.

A study of tea culture in the various tea countries shows that methods, whether considered in broad outline or in ultimate detail, vary widely.

The tea growing centres fall into two groups. First there are the historic tea countries of China and Japan, where tea growing has been practised as a village industry for many centuries, and where methods are often old-fashioned and sometimes primitive. Of recent years, however, Japan has realized the value of science and machinery, and her industry is in many ways as up-to-date as that of India or Java. China, too, is awakening and an extensive re-organization programme for the modernization of the industry was published some years ago.

The second group of tea countries includes India, Ceylon and the Dutch Indies, where the industry represents mainly European interests, working with modern machinery, producing tea wholesale for western markets and putting the results of modern science to the service of agriculture and manufacture.

In this chapter an outline of the methods followed in the chief tea countries is given, largely with the object of indicating their differences.

The Planting of Tea

Tea is generally propagated from seed. In Formosa most of the propagation is done by layering, the process being carried out as follows. A lateral branch of the

bush is taken, the bark scraped an inch or so below an eye and then pegged down into the soil so that the eye is buried. When the layer has rooted it is cut from the parent branch and planted carrot fashion.

Propagation both by layers and by cuttings is sometimes practised in Japan with success. In the month of June a shoot about 6 inches in length is cut and, after having most of the leaves and buds removed, put into a nursery. The cutting is transplanted two years later.

In China and Japan it is usual to dispense with nurseries and to plant the seed directly in the field, close together either in lines or in circles of about 18 inches diameter. In the former case a row of tea resembling a box hedge is obtained, and in the latter hive-shaped clumps which eventually merge into each other, giving an undulating row of tea.

In China nurseries are occasionally planted. The seed ripens in October and is kept in damp sand until the spring, when it is germinated and planted in a nursery. Transplanting takes place the following spring after the monsoon change.

In India, Ceylon and Java nurseries are practically always employed. Seed is occasionally planted direct, and in this case two or three are put at each stake, and the strongest plant selected after a few months. Seed at stake requires much care and attention, and in North-East India often needs watering before the break of the monsoon.

Planting in North-East India presents problems not met in Ceylon and Java where there is no very hot, dry period. The shading of nurseries is, on account of the drought, advisable in Assam and essential in Cachar and Sylhet. In the last two districts it is preferable to transplant in June or July after the monsoon has definitely arrived, rather than plant in the spring and risk the effects of the pre-monsoon drought.

In North-East India the nurseries are put out in the early part of the year, and at transplanting the seedling is lifted with a clod of earth carefully cut to avoid root damage and disturbance. Transplanting usually takes place when the seedling is from six months to two years old, but sometimes older plants are lifted. In such cases it is often necessary to cut the tap root, a practice not encouraged for although such a plant may give a healthy bush it is often a poor leaf yielder.

In Java and Ceylon, when the seedling is 14 to 18 months old it is cut down to a height of about 6 inches and transplanted as a ' stump '. The stump is pulled out of the soil, after the latter has been loosened, and planted without the particular care necessary in North-East India.

In Sumatra, where during periods of rapid expansion tea is put out all the year round, several methods of planting have been employed, and the percentage success observed in each case. Seed planted at stake gives 50 per cent to 60 per cent successes. Two-month old plants, transplanted without earth, give 80 per cent to 90 per cent successes. At this stage the seedling is still feeding on the cotyledons and the shock of transplanting is apparently not serious. This method has the disadvantage that selection is difficult with such young plants. With older plants, ' stump ' planting has been found to give about 70 per cent successes, whilst clod planting with one-year old plants gives about 90 per cent successes.

Pruning and the Formation of the Tea Bush

In its natural state the tea plant is a shrub or tree, and some varieties if allowed to grow may reach 60 feet in height. For convenience in plucking the bush must be kept at a height of about three feet or less.

In India, Ceylon and Java, the formation of a bush giving the maximum crop after a minimum period spent

in its building, is a problem which has received much study. In China and Japan the same problem does not arise since the group of plants which forms a complex 'bush' does not need the same amount of building and shaping as the single plant dealt with in other countries. In China and Japan each individual plant in a group resembles in its function a single branch in a carefully pruned simple bush as grown in India.

In China the tea is plucked as a rule four times a year and all the young leaf is taken. This treatment, combined with the cool climate of most of the China tea districts, does not allow of very vigorous wood growth and precludes any need for frequent drastic pruning.

In Japan the leaf is plucked with shears about four times a year, after having been given some growth before the first plucking. At the last plucking of the season the bushes are clipped to a few inches below the old plucking marks, which procedure is equivalent to a top prune. This last pluck consists of young and old leaves and twigs, which are made into Bancha, or third-quality tea.

In Japan, as in China, the bush develops into a clump of gnarled, single-stemmed plants of various heights which give a plucking surface extending from the crown of the bush to the soil. When the bush appears to be exhausted it is cut low down, after which the leaves grow bigger and the bush improves for about five years. Heavy pruning is only resorted to in extreme cases, for a high bush is said to give a good quality tea.

As previously indicated, the process of turning a single seedling into a bush with a plucking table 4 or 5 feet in diameter is one of importance in India, Ceylon and Java. In the last two countries, where 'stumps' are planted, the cut plant sends out several branches, one or two of which run up in the centre and monopolize the strength of the plant. In Java the treatment of such a

bush is as follows. About two years after transplanting, the plant, which is now cone-shaped, is cut straight across in a plane parallel to and about 20 inches from the ground. Some of the strong, centre branches may be cut lower than the others, a process which tends to make the bush develop the side branches. In this way spread is obtained and a large plucking surface formed.

The top of the bush after this first pruning presents a roughly level and circular plane, from which young shoots soon begin to develop. A 'tipping' height is now fixed, for example at 28 inches, 8 inches above the pruning level. The shoots of two leaves or three leaves and a bud which grow above the plucking level are plucked at intervals of a week or 10 days for perhaps the next two years. At the end of this time the flushes become less vigorous and the crop begins to tail off. There is now more than 8 inches of two-year old wood above the last pruning mark, and above this the plucking marks of the last two years. This two-year old wood is cut 2 or 3 inches above the last pruning mark, making the height of the frame now about 23 inches. Plucking goes on as before, and at the end of another two years or so another top prune is necessary. With each top prune the bush gets higher, till eventually it is either too high for convenience in plucking, or the bush becomes moribund and the crop decreases.

At this stage heavy pruning is necessary, and the bush is cut back, probably at a height of 18 inches from the ground or at some height which offers good, straight, un-knotted wood to cut on. After this pruning the young shoots appear again, although more slowly than when lighter wood was cut, and the plucking cycle proceeds as before.

Broadly speaking the system just described is the one followed not only in Java, but also in Ceylon and India.

In Java it is common to prune up five times and then to cut back on heavier wood.

In Ceylon, the 'stump' after it is securely rooted and has grown a stem about 1¼ inches in diameter near the ground may be collar pruned, i.e. cut off near the ground. In this manner a secondary or coppice growth is produced round the collar which when developed may be cut at a height of about a foot, and a broad bush thus built up.

As an alternative to collar pruning the bush may be formed by judicious centring in the manner described in the case of Java. Centring avoids the loss in crop in the early years which follows collar pruning.

In India, where 'stump' planting is not practised, but the whole plant transplanted, both collar pruning and centring are employed, although the former system has of recent years been largely abandoned. It is usual to cut the bush straight across at a height of about 18 inches about a year after planting. Subsequent pruning, either annual or biennial, is made by cutting the bush an inch or two above the previous cut. When the bush gets too high or the crop falls, a heavy prune is made, preferably on straight wood below the knots which collect round the top prunings.

If the bush is collar pruned, the second prune is carried out at a height of about a foot above the collar after one or two years. The next cut is made at about 16 inches and subsequent prunings at an inch or two higher each time.

It might be supposed that, since by means of pruning the frame of the bush can be renewed, the tea bush would go on indefinitely. This is by no means the case since each time thick wood is cut most of the branches die back a few inches, leaving a snag of dead wood. This snag may fall off and the wound callous over completely, but in many cases, depending largely on the cleanness

and position of the cut, the health of the bush and the weather, fungus diseases attack the wound and eventually kill the branch. A debilitated bush and a reduced crop are the result, and in many cases further heavy pruning causes the death of the bush.

The economic age of the tea bush under present field methods in North-East India is not known. In Dehra Dun it is claimed that some of the bushes, which yield at the rate of about 320 lb. per acre, are almost 100 years old. In Assam, where in some districts a yield under about 560 lb. per acre is uneconomic, the useful life of the bush is probably not more than 50 years.

In Ceylon and Java where the bush flushes throughout the year, it is usual to prune at periods varying from 18 months in the plains to four or even five years in the highest altitudes. In North-East India where flushing ceases for three or four months in the cold weather, it is the rule to prune either annually or biennially during the non-flushing period. When tea is left unpruned for a year the bushes are not touched when flushing ceases in December, and the spring flush is then plucked as it appears, much in the same way as the bushes are plucked in China. Arguments for and against unpruned tea will be marshalled in a later chapter on tea in North-East India.

Plucking

In China, Japan and North-East India the bush begins to send out new shoots in the spring and, if plucked, continues to flush throughout the summer. Unless stimulated by plucking, there are two main periods of growth of the bush, one in spring and the other in autumn. In Java and Ceylon the bush is plucked throughout the year, although the crop is by no means evenly distributed over the season.

In most countries the leaf is plucked by hand. In Japan plucking is done with light shears, fitted with a wire cage or bag on one blade to collect the leaf, and a scoop on the other to push the leaf into the bag. Plucking with shears is also practised in Trans-Caucasia. Plucking is a process requiring discrimination and as long as labour is cheap and plentiful it is unlikely that mechanical plucking will be generally adopted.

In China it is usual to take all the young leaf when it appears in the spring. The stripped bushes give a second flush in June and perhaps two more, one in August and one in September. When tea was first grown in India the Chinese system of plucking was employed. This gives a big early crop, April being the biggest month, and no late crop, September being a small month.

It was soon observed in North-East India, however, that to get the most out of the bush, young leaf with axils capable of producing shoots, should be left after the first flush. Accordingly, before the bush is 'tipped', shoots which include five leaves or so are allowed to develop, and then only the top two or three are plucked. In this manner the spring crop is postponed and April becomes a small month. By virtue of the extra flushing points left after the first plucking, the early loss in crop is more than made up, and September and October become two of the biggest months of the season.

The question of how many leaves to leave after the first plucking has given rise to much experiment. Nowadays, three or four leaves, equivalent to a stem growth of 6 to 8 inches with plants of the Assam varieties, are left on a top pruned bush. On a bush which has been pruned back, a much longer initial growth is necessary for the building of a sturdy frame and, as a rule, bushes are never plucked below a height of 26 inches from the ground.

Having decided how much leaf to leave before 'tipping' the bush, as the process of taking the first flush is called, the question which now arises is, how many leaves shall be left in subsequent flushes. Although each leaf axil is a potential producer of new shoots, a bush with too many young leaves has little incentive to flush, and the shoots become *bhanji*, or dormant. Hence a happy mean must be struck, and this has been found in some districts to consist in leaving one leaf after the second flush, and in others in taking everything which appears above the plucking table formed by the 'tipping', leaving only the *janum* or prophyll.

Experience in Assam has shown that, for ease in plucking and for crop, a flat plucking table pays. On this account it is customary to pluck according to a measure from the ground rather than according to a number of leaves above the pruning or last plucking mark. This latter method gives an irregular plucking surface which cannot be plucked so quickly as a flat one.

It happens often that one or more shoots on the bush grow more rapidly than the others, and when the bush is plucked these shoots consist of three or four leaves. In such cases the top two leaves and a bud are plucked and the other leaves 'broken back' and discarded. In the case in point, one or two leaves below the plucked shoot would be taken and thrown away. In this manner the flat plucking surface is retained.

No definite ruling can be laid down regarding the plucking of a tea bush. Hard plucking may pay in crop for a few years, but may produce a debilitated bush which in the end is an economic failure. The best treatment varies from district to district and depends largely on the health of the bush.

In Java and Ceylon experience has shown that plucking the shoot immediately above the *janum* does not

pay as a rule. In Ceylon, the initial plucking after pruning is usually much lower than in Assam, but subsequent pluckings are made above a leaf. In Ceylon and Java the bushes get higher at each plucking, because of the leaf which is left after each round, but in India the height changes little after the ' tipping '.

Having discussed the *length* of the plucking, i.e. the amount of leaf left after taking the shoot, it remains to discuss the fineness of the plucking. A fine shoot consists of two leaves and a bud, still soft and succulent. With China varieties and with Assam varieties during an attack of Green fly more than two leaves may be plucked and the leaf still be fine. Coarse plucking includes shoots which are large, generally shoots of more than two leaves and a bud, and *bhanji* or dormant shoots.

Since plucking is only carried out every week or so, it will be understood that the leaf appearing above the plucking table will consist of shoots in many stages of development. Some will be just ready and will consist of two or three leaves and a bud according to the standard of plucking adopted. Some will be under-developed and yet too far advanced to be left till the next round. Some will be over-developed, and some shoots may be *bhanji*. Even with careful plucking an assortment of shoots in different stages of development will be obtained and as a rule not more than 60 per cent of shoots of standard fineness will be gathered under conditions in North-East India.

The quality of the tea made varies closely with the fineness of the leaf and also, although not so markedly, with the closeness of the plucking. In North-East India the best tea is made from fine leaf plucked closely, i.e. soft and small shoots plucked above the *janum*. In Darjeeling the idea is sometimes expressed that flavour is most marked when the plucking is fine and long. For

strong liquoring teas, however, fine and close plucking certainly pays.

The Cultivation and Manuring of Tea

Tea grows best on a clean soil, free from competition with other plants. Since the tea crop consists of the leaf the commonest manures used are nitrogenous, because these make for vegetative growth.

Regarding the cultivation of tea, Chinese practice suggests that the soil be loosened in March, and cultivated in the summer to destroy the weeds. After the plucking season is over the soil should once more be cultivated.

In Japan it is customary to cultivate the soil before the first plucking and again in June and September. Trenching, with the burial of weeds, or deep hoeing is carried out in the autumn. The soil is frequently covered with a mulch of bamboo leaves in the autumn which is lifted for cultivation and buried the following autumn.

In North-East India experiments in cultivation have shown that soil disturbance *per se* does little to increase the crop, but the removal of weeds, if there are any, does good. Trenching and very deep cultivation has been found to give no increase in crop and may, if the roots are unduly disturbed, actually depress the crop. Nowadays it is customary to prune the bushes so that the branches and foliage as far as possible shade the soil and so retard weed growth. In this manner the amount of cultivation needed is greatly reduced. It is common to light hoe to a depth of about 4 inches from three to five times a year, mostly in the rainy season when weed growth is rapid. A deep hoe is given at the end of the plucking season and this usually penetrates to a depth of about 6 inches.

In Java, as in India, the general consensus of opinion is against frequent soil disturbance. It is common to

weed selectively, leaving desirable, shallow rooting weeds, or to cover the soil with low growing green crops if the bushes themselves are too small to control weed growth.

In Ceylon it is usual to clean-weed the soil, although the custom followed in Java regarding selective weeding and the employment of ground green crops is making some headway. On the slopes a clean soil allows of soil wash, and soil erosion is a serious problem in Ceylon.

Turning now to the question of the manuring of tea, this is generally practised in most tea countries, with the possible exception of China for reasons discussed in the last chapter.

In Japan the common manure is night soil added in enormous doses, giving up to 230 lb. nitrogen per acre. Oil cake is also used. The Japanese tea farmer is prejudiced against artificials, like sulphate of ammonia, which he considers spoil the quality of his tea. He is also prejudiced against green crops, although experiments have shown that these actually improve quality.

In North-East India the use of artificial manures has increased rapidly in the past few years, and systematic manuring is now the rule in most gardens. An account of manurial treatment in this area is given in a later chapter. It is sufficient to say here that, in addition to growing green crops where possible, many gardens add on an average nitrogenous manures giving about 30 lb. nitrogen per acre per annum, together with somewhat smaller quantities of potash and phosphoric acid. Most of the manures are added in the form which happens to be cheapest, usually as artificials.

In Java, artificials are not used to the same extent as in India. Sulphate of ammonia added with some phosphoric acid before pruning is common. It has been found that potash manures do not increase the crop.

Shade trees and green crops are used extensively, the latter being cut and left to grow again, a practice possible where rain falls all the year round.

In Ceylon the use of artificials is a much older practice than in India. As in Java, cattle manure is seldom used, but most of the ordinary artificial fertilizers and also organic manures are in use. Mixtures are often added a month or so before pruning and about eight months after. The pruning mixture may give 30 to 40 lb. phosphoric acid and about 15 lb. each of nitrogen and potash per acre, whilst the second mixture may give about 40 lb. nitrogen, 15 lb. phosphoric acid and 30 lb. potash. Green manure, in the way of loppings from shade trees, is added in large quantities to the soil.

The Pests and Blights of Tea

The tea bush is subject to attack by many insect pests and fungus diseases, and the list of known pests and blights is already formidable.

The most serious and at the same time most widespread insect pest is the tea 'Mosquito' Bug (*Helopeltis theivora*), whilst the Red Spider (*Tetranychis bioculatis*), though perhaps not so serious, is even more widespread than the former. Various crickets, beetles, borers, caterpillars, bugs, thrips and mites all do more or less damage at certain times and in certain districts.

The tea plant, in common with others, is attacked by many fungi. Twenty-five years ago only about a dozen tea disease-producing fungi were definitely identified. At present about 150 fungus diseases have been reported attacking leaf, stem, branches and roots. Comparatively few of these fungi cause serious damage.

An account of the pests and blights in the various tea countries is given in the chapters dealing with these countries.

THE PREPARATION OF TEA

Tea leaf may be prepared or cured in a number of ways. Any treatment by which the leaf is given keeping qualities so that the caffeine it contains will be available when needed, serves, in the broadest sense, as a method of preparation. The development of aroma and flavour in tea, and the manipulation of the leaf so that it shall give liquors with certain qualities, are actually subsidiary to the prime object of tea preparation.

The most primitive people who prepare tea do so by pickling the leaf. In Upper Siam the fresh leaf is steamed above boiling water, and then preserved in bundles in pits lined with leaves. The extract of these leaves is drunk and the leaf itself is chewed by the natives when they have heavy work to do. This type of preparation is met with modifications amongst the Shans, which name implies a group of allied tribes inhabiting South Yun-nan and the northern tracts of Siam and Burma. In Siam the product is called 'mieng' or Lao tea, in Burma 'letpet' or 'leppet' tea. Leppet tea is distinguished from the product made in Siam by not being steamed but boiled and then kept wet in bamboo cases or in pits. It is eaten with oil, garlic, dried fish, etc. Sometimes after boiling the leaf is dried, and the dried product is boiled again before using and drunk with salt water.

It will be understood that the finer qualities of tea are missed in pickled leaf, which is taken solely with the object of obtaining the stimulus from the caffeine, although the leaf itself has a certain food value when eaten.

In all tea countries other than the Shan States the leaf is converted into black or green tea. The latter mode of preparation is comparatively simple, and consists essentially of heating the fresh leaf, rolling it, and drying it. The highest qualities of the leaf are developed in the

preparation of black tea, which includes rolling and fermentation before the leaf is fired or dried. Black tea is referred to as fermented tea and green tea as unfermented tea. Oolong teas are lightly fermented and their liquors have characteristics intermediate between those of green and black teas. These teas are spoken of in the trade as semi-fermented. For convenience in transport both black and green teas are made into brick form.

A brief description of the preparation of green, black and brick tea will now be given. In preparing green tea, the leaf is first heated to a temperature above 160° F., which makes it soft and pliable for rolling, and at the same time inactivates the leaf enzymes and makes fermentation impossible. The heating is carried out either by steaming the leaf or by placing it in a hot iron pan. After heating, the leaf is rolled and partially dried alternately, till it is too crisp for further manipulation, after which the drying is completed.

All the tea made in Japan is green tea, and much of that exported from China is also green. Green tea is made in a few gardens in Assam, which usually manufacture on contract, and by most of the concerns in Ranchi, Dehra Dun and the Kangra Valley in north India.

In Japan the preliminary heating of the leaf is carried out by steaming and the subsequent rolling is sometimes done by hand and sometimes by machine. In China the preliminary heating is done in a hot pan and the rolling is done by hand. In Assam and Ranchi the leaf is steamed, but in Dehra Dun it is panned, whilst all the subsequent rolling and firing is done by machinery, when green tea is made in any part of India.

If green tea is carefully made there is little difference between the composition of the fresh leaf and the finished tea. The only notable alteration is a decrease in the soluble tannin which may fall, for example, from

15 per cent in the fresh leaf to 12 per cent in the prepared tea. The liquors of green teas are thin and light in body and a greenish yellow in colour.

The preparation of black tea is more complicated than that of green tea. In China the process is one capable of an infinite number of variations and the following account can only be taken to cover the general case.

First the plucked leaves are quickly withered in the sun for about two hours with frequent turning. They are then spread thinly in a cool place for about half an hour, after which they are manipulated and gently rolled in the hands. The rolling cracks and bruises the leaves and exposes some of the leaf juices to the air. After rolling, the leaves are again spread thinly in a cool place for a short period and then rolled again. Rolling and spreading alternate several times till fermentation has proceeded far enough, as judged by the aroma. Fermentation is now stopped by throwing the leaves into a hot pan heated to a temperature of about 160° F., or higher. The leaves are cooled and then rolled again and manipulated, and again placed in a hot pan and partially dried. Alternate rolling and partial drying take place several times and the leaves are finally dried on bamboo trays over a charcoal fire.

The preparation of Oolong tea is very similar to that of black tea in China. For details of the process reference should be made to the account of tea in Formosa, which country produces the finest Oolong teas.

Brick tea is made in China for export to Mongolia, Tibet and Russia. Some years ago its preparation in India was seriously considered, but the project was not developed. Brick tea intended for Tibet consists of leaf, stalk and even twigs, whilst that for the Russian market is made mainly from tea dust and siftings. Both black and green teas are compressed into bricks and tablets.

In the modern factories at Hankow the carefully graded dusts are steamed in cotton bags and poured into wooden moulds in which the brick is formed by means of hydraulic pressure. The making of the poorer grade bricks for Tibet is largely in the hands of the Chinese. The leaf is steamed until it is moist and pliable and then rammed into wooden moulds, where it is left to dry and harden.

When tea cultivation was introduced first into Java in 1825, and India in 1835, Chinese methods of preparation were employed. The industry developed steadily in Assam and northern Bengal and in these areas, collectively referred to with regard to tea as North-East India, hand methods were gradually replaced by machinery from 1870 onwards, and distinct modifications in the Chinese process were introduced.

In Java and Ceylon the industry developed at a later date, and these countries have taken the methods of North-East India and adapted them to local conditions. By virtue of these changes, as well on account of different climatic conditions and variety of bush, black teas from India, Ceylon and Java differ considerably from those of China.

The preparation of tea in the countries where the industry is European controlled has become so mechanized that it is correct to speak of tea manufacture, rather than preparation. Manufacture consists of four definite processes, withering, rolling, fermentation and drying.

In careful manufacture all the important chemical changes take place in fermentation, a process which starts as soon as the leaf is damaged in the rollers. Properly withered leaf has almost the same chemical composition as fresh leaf in manufacture along European lines, but having lost its turgidity, it is in a fit physical state for rolling.

During fermentation the tannin in the leaf is rapidly oxidized by the aid of leaf enzymes. In this manner red products are formed which give a black tea infusion its characteristic colour and largely account for the body of the liquors. At the same time much of the oxidized tannin is rendered insoluble by leaf proteins, and fermented leaf only contains about half the soluble tannin present in fresh leaf. During fermentation the tea essential oil is formed and the substances giving the flavour and aroma of certain black teas are developed.

When the leaf is fired the reactions which constitute fermentation are stopped, leaf enzymes are inactivated and the leaf is given keeping qualities.

It is usual to wither the leaf in a period varying from 12 to 20 hours, during which time the moisture content is reduced from about 77 per cent to about 60 per cent, more or less according to the temperature at which withering is carried out. The lower the temperature the more fully is it usual to wither.

Where possible the leaf is withered in the open on wire or hessian racks placed in the shade. Where open-air withering is impossible closed lofts are used, and in them the temperature and air movement is controlled so that the necessary degree of withering may be obtained in a specified time.

After withering, the leaf is rolled in mechanical rollers. A roller consists of a box or cylinder, without top or bottom, which rotates on a brass or stone table fitted with battens. These battens churn the leaf constantly and induce a general movement throughout its bulk. There is a movable cap or top to the box which can be lowered on to the leaf to exert various degrees of pressure during rolling.

Leaf is fed into the roller by a hopper and first rolled lightly for about half an hour. Then a trap door in the

bottom of the roller is opened and the leaf let fall into a trolley, in which it is conveyed to a sieve which separates the coarse from the fine leaf. The latter, sufficiently damaged, is taken to the fermenting room, whilst the former is put back into the roller and rolled with pressure.

Rolling and sieving alternate for two, three or four further periods each of about half an hour's duration. At each sieving the leaf, which has heated up in the roller, is cooled and vigorous oxidization is allowed to go on. There are many different systems of rolling designed to meet natural conditions of temperature and to deal effectively with the type of leaf plucked.

The fermenting room is a cool, humid space where the rolled leaf can be spread thinly and allowed to oxidize for a period, including rolling, of about 3½ hours. The exact time varies and is generally fixed to coincide with the full development of the tea aroma. When fermentation is complete the leaf is taken to the firing room, where it is fired or dried.

Modern tea firing machines, of which there are several on the market, consist of a stove for heating air and a fan which draws the hot air from the stove and forces it into the drying chamber. Inside this chamber is a series of perforated metal trays which move so that the fermented leaf fed on the top tray works its way to the bottom tray and so to the discharge. The hot, dry air as it enters at the bottom of the drying chamber passes first through the trays carrying the leaf about to be discharged, and gradually finds its way out at the top of the machine where, cool and moist, it meets the incoming leaf.

The leaf is dried at an even rate in about 25 to 40 minutes. The temperature of the air blast as it enters the drying chamber is 180° to 220° F. The fired tea

contains about 3 per cent moisture or less, which content rises to about 6 per cent whilst the tea is being sorted.

The methods of manufacture peculiar to various countries are described in later chapters. Some account of the sorting, grading and classification of teas is also given later.

PART II

THE CHEMISTRY AND PHARMACOLOGY OF TEA

CHAPTER V

OUTLINE OF THE CHEMISTRY OF TEA

Brief account of the work on the chemistry of tea—The changes occurring during the manufacture of tea—The composition of tea leaf and tea—The quality of tea—Government examination of tea.

THIS chapter and the next two deal with the chemistry of tea whilst the pharmacology, an extension of the same subject, is discussed in the succeeding chapter.

The chemistry of tea is a subject which can only be dealt with in outline in a work like the present. This chapter gives an account of the development of tea chemistry and expresses the generally accepted views on the subject. Some mention of the more important scientific publications on tea is made.

The next chapter treats in greater detail with the properties of various constituents of the tea leaf, and assembles much of the work carried out on this subject in Assam during recent years. This is followed by a chapter describing manufacture from the chemical point of view and correlating the properties of the finished product with the method of manufacture.

BRIEF ACCOUNT OF THE WORK ON THE CHEMISTRY OF TEA

The earliest work on the chemistry of tea was carried out on the finished product. Mulder,[8] Péligot[9] and Rochleder[10] made investigations between 1840 and 1850. The first two made partial analyses and Rochleder studied

[8] P. Mulder, *Ann. Physik. Chemie,* Leipsig (1838), xliii, 161.

[9] E. Péligot, *L'Institut,* Paris (1843-45), 238-9.

[10] Rochleder, *Ann. Chem. Pharm. Liebigs,* Heidelberg (1847), lxiii, 202.

the tannin in tea. Hlasiwetz and Malin[11] detected gallic acid in tea in 1861 and later claimed to have found quercetin in China tea.

By 1880 fairly full analyses of tea were available and Blyth,[12] in a publication giving many figures, suggested that the day was not far distant when tea would be judged by analyses supplemented by tea tasters' reports.

The earliest chemical analyses on fresh leaf were made between 1880 and 1890. In 1886-87 Kellner[13] made detailed analyses on leaf and on the ash of leaf, gathered at intervals throughout the year. Kosai[14] showed that during the manufacture of black tea the main change was the loss of the water-soluble tannin content of the leaf. This loss was shown to be much smaller in green tea than in black tea manufacture. By this time analyses showed the amount of fibre, protein, tannin, caffeine, ash, sugars and colouring matter in the leaf. As science advanced and the knowledge of plant chemistry increased, details regarding the groups of substances making up the tea leaf were supplied.

The first systematic work on the chemistry of tea and the changes taking place during manufacture was carried out by Bamber in India and Ceylon, and by van Romburgh, Lohmann and Nanninga in Java. Much of Bamber's work is published in his book, *The Chemistry and Agriculture of Tea*[15] and his paper on Ceylon tea soils.[16] Van Romburgh, Lohmann and Nanninga published their work in the journals of the Agricultural Department at

[11] Hlasiwetz and Malin, *Jahresberichte Fortschritte Chem.* (1861), 932 and (1867), 732.

[12] A. W. Blyth, in a paper published by Chas. Griffin & Co., London, 1879, quoted by *Tea Cyclopædia*, Calcutta (1881), 19.

[13] O. Kellner, *Jour. Chem. Soc.*, London (1887).

[14] Y. Kosai, Researches on the Manufacture of various kinds of Tea, Imp. Coll. Agric., Tokio (1890) bull. 7.

[15] M. K. Bamber, *The Chemistry and Agriculture of Tea*, Calcutta (1893).

[16] M. K. Bamber, *Ceylon Tea Soils*, Colombo (1900).

Buitenzorg, Java. A résumé of the results of fifteen years of their investigations has been made by Deuss.[17]

Of the three important substances in tea, caffeine, tea tannin and the essential oil of tea, most work has been done on tea tannin and the changes it undergoes in manufacture. Deuss prepared pure tannin from the dried leaf and concluded that the molecule contained 8 hydroxyl groups, at least one ketonic group and no carboxyl group. The empirical formula he found to be $C_{20}H_{20}O_9$.[18] Deuss[19] places tea tannin in the group of condensed tannins of Freudenberg's classification.[20] He was not able to show the presence of the phloroglucinol group in the tannin molecule. M. Tsujimura, working in Japan, gives a detailed structural formula for tea tannin and considers the empirical formula to be $C_{22}H_{18}O_9$.[21]

The changes undergone by tannin during manufacture and the variation of the tannin content of the tea leaf are dealt with in the next chapter.

Little work has been done on the caffeine in the tea leaf beyond its estimation, and indeed this subject does not call for much study. Theophyllin has been isolated from tea in minute quantities[22] and the presence of xanthine, hypoxanthine, adenine and theobromine, all members of the purine group and related to caffeine, has been reported.

The essential oil of black tea has received some study. Van Romburgh found that freshly fermented tea leaf yields a distillate containing traces of an alcohol and small quantities of an oil. From 2,500 kg. of

[17] J. J. B. Deuss, *Meed. Proef. Thee,* Buitenzorg (1914), No. 31.

[18] J. J. B. Deuss, *Meed. Proef. Thee,* Buitenzorg (1913), No. 27.

[19] J. J. B. Deuss, *Rec. trav. chim. Pays-Bas,* Leyde (1923), xlii, 1,053.

[20] K. Freudenberg, *The Chemistry of Natural Tannins,* Berlin (1920).

[21] M. Tsujimura, *Bull. Agric. Chem. Soc. Japan,* 6, 70-5 (1930), 7, 23-8 (1931).

[22] A. Kossel, *Ber deut. chem. Gesell.,* Berlin (1888), xxi, 2, 164.

fermented leaf, 130 c.cm. of oil was obtained. This quantity of oil contained about 1·1 gm. of methyl salicylate (oil of wintergreen). The steam distillate contained methyl alcohol and a very volatile product giving aldehydic reactions. Traces of acetone were also detected. The actual oil, which collects as a drop on the water distilled from tea, has a penetrating odour of tea. It has a specific gravity of 0·866 at 26° C., and is faintly optically active. Van Romburgh separated the oil into two parts, one boiling above and the other below 170° C. The fraction of lower boiling point is a colourless liquid having the odour of tea, and consisting of an alcohol with the empirical formula of $C_6H_{12}O$. It is probable that this alcohol is β-γ-hexenol. The fraction boiling above 170° C. contains the oil of wintergreen.[23]

The tea essential oil is not present in appreciable quantity in fresh leaf, neither is it found in green tea. Its chemistry has not been more fully worked out because of the minute quantity present in black tea.

The substances connected with special flavours occurring at certain times of the year and distinctive flavours in teas from certain districts have not yet received any study. The minute quantities in which the flavour-giving substances occur makes their study difficult.

Chlorophyll, the green colouring matter of plants, and its allied pigments constitute about 1·5 per cent of the dry matter of the tea leaf. During the manufacture of tea some of the chlorophyll is destroyed.

Other pigments, members of the flavone and anthocyan groups, occur in small quantities. Deuss failed to find quercetin in tea or tea leaf (as reported in 1861 by Hlasiwetz and Malin) but has shown that quercitrin

[23] P. van Romburgh, *Schimmel's Berichte,* Leipsig (Ap. 1897), 39 (Ap. 1898), 60 (Oct. 1920), 65.

occurs in both to the extent of 0·1 per cent.[24] Quercitrin is a flavonol which in hydrolysis yields quercetin and rhamnose, a sugar.

Shibata[25] has shown that tea grown in the sun contains a greater quantity of flavones than that grown in the shade.

Anthocyans, a group of pigments related to flavones, also occur in tea leaf and play an important part in the quality of green tea.[26] Like flavones they are increased in the leaf when grown in the sun. Reference to the relationship between anthocyans and the quality of green tea will be made later.

Figures relating to the total sugar in the tea leaf are available in number. Traces of the sugars, galactose and arabinose have been detected in the leaf.[27] In Japan, the total sugar has been shown to be about 1·2 per cent of the dry matter in the leaf, of which 0·5 per cent to 1·0 per cent is cane sugar. The cane sugar content varies according to the manner in which the bush is grown, being greater in bushes shaded from the sun.[26]

Estimations of the cellulose, soluble gummy matter, starch, protein and proteose content have been made by various observers, and figures obtained by estimations based on modern methods are available.

The Changes occurring during the Manufacture of Tea

The changes occurring during the manufacture of black tea have been the subject of considerable study. As long ago as 1890 Kosai[14] gave analyses of fresh leaf

[24] J. J. B. Deuss, *Rec. trav. chim. Pays-Bas,* Leyde (1923), xlii, 4th ser., vol. 3.

[25] K. Shibata, *Bot. Mag.,* London (1915), xix, 343.

[26] *The Chemistry of Green Tea,* compiled by the Tea Experimental Station, Kanaya, Japan, 1923.

[27] A. D. Maurenbrecher and B. Tollens, *Zeit. Rubenzücher Indus.,* Berlin (1908), 1,044.

and of green and black tea made from similar leaf. He showed that in green tea manufacture there is some decrease in the water-soluble tannin content, whilst in black tea manufacture a half or two-thirds of the soluble tannin may be lost.

During the manufacture of black tea most of the change takes place in fermentation. In withering, the most noticeable change is the loss of water by reason of which the leaf becomes flaccid and assumes a condition suitable for rolling. The leaf cell wall becomes more permeable during withering, and withered leaf placed in water gives a coloration with ferric chloride within a few minutes, whereas fresh leaf must be steeped for many hours before such a result is obtained. The colour referred to is due to a compound formed between ferric chloride and the tea tannin in solution.

During withering the leaf continues to respire, although the rate of respiration decreases as the wither proceeds, but does not wholly cease even after the leaf has been rolled. Respiration involves the taking in of oxygen and the giving out of carbonic acid gas. As a result, the total solid matter in the leaf decreases during withering to an extent which may amount to 5 per cent of the total.

The tannin content of the leaf does not change during withering. The water-soluble nitrogenous compounds in the leaf, other than caffeine, increase slightly during withering.

Deuss[28] studied the chemical modifications in the leaf during normal withering and observed no important changes. He found that a wither at too high a temperature or at too quick a rate reduced the water-soluble matter in the leaf.

[28] J. J. B. Deuss, quoted by H. Neuville, *Technologie du Thé*, Paris (1926), 104.

Yet, in spite of the fact that no important chemical change in the leaf is brought about during withering, a good wither is essential if good black tea is to be made. It is probable that a change in the physical state of some of the substances in the cell sap, brought about by withering, may influence the course of the changes taking place later on in manufacture. Thus, the physical state of the leaf proteins and their capacity to precipitate certain tannin bodies is probably influenced by the withering of the leaf.

The object of rolling is to break the leaf cells, mix the juice thereof and expose it to the air. From the point of view of the chemical changes attending this process, rolling is intimately connected with fermentation. The amount and kind of change taking place during fermentation is influenced by the degree and rate of the wither and also by the system of rolling.

When tea leaf is rolled or crushed and exposed to the air, oxygen is absorbed and the leaf turns red owing to the oxidization of the tannin. At the same time the essential oil of tea is formed. These changes are collectively spoken of as the 'fermentation' of tea. The leaf will not ferment without oxygen.[15] Nanninga showed that the longer the fermentation the greater the percentage of insoluble substances in the leaf. In fermentation he found that the total soluble extract fell from about 62 per cent to 50 per cent, and the same kind of change was observed with leaf from both China and Assam varieties of bush.[29]

The changes which constitute fermentation proceed in best order at temperatures between about 75° and 80° F. At temperatures below these the oxidization of the tannin is so slow that by the time it has proceeded far enough aroma is often lost. At temperatures much above 80° F. the tannin oxidization is too rapid and may

[29] A. W. Nanninga, *Korte Ber.'s Land Plantentium,* Buitenzorg (1901), 12.

be ready before the aroma has had time to develop. At temperatures above 110° F. fermentation does not proceed normally and the leaf tends to turn yellow rather than red.

The rapid oxidization of tea tannin during fermentation is due to an enzyme, an oxidase, in the leaf which was discovered almost simultaneously by Bamber in Ceylon[16] and Nanninga in Java.[30] In Japan, Azo[31] also showed that the oxidization was assisted by an enzyme, and concluded that the preliminary heating process in green tea manufacture inactivated this enzyme and accounted for the chief difference between green and black teas.

Mann studied the enzyme[32] and later Bernard and Welter took up the problem.[33] The enzyme is separated from the leaf by pulping the latter with hide powder to remove the tannin, after which the pulp is extracted with water which dissolves the enzyme. The latter is precipitated by alcohol as a slimy mass which dries to a whitish powder. About the same amount of oxidase was found in all parts of the shoot, and no appreciable change in the amount was observed during manufacture. The activity of the enzyme, as measured by the guaiacum reaction, was found to be about the same between 77° and 167° F. At about 173° F. the action became slow and above this temperature stopped altogether. The enzyme was only permanently incapacitated if kept for some time above 176° F.

Bernard[34] has isolated yeasts from the fresh leaf, and as a result of experiments concluded that these micro-organisms do not play a major role in tea fermentation. The opinion is held by some observers that yeasts may be

[30] A. W. Nanninga, *Vers. Onder. Java gecult. Theeen*, Buitenzorg (1900).

[31] K. Azo, *Bull. Agric. Coll.*, Tokio (1901).

[32] H. H. Mann, *The Ferment of the Tea Leaf*, Calcutta, Pts. 1, 2 and 3.

[33] C. Bernard and H. Z. Welter, *Meed. Proef. Thee*, Buitenzorg (1911), Nos. 12 and 13.

[34] C. Bernard, *Meed. Proef. Thee*, Buitenzorg (1907), No. 5.

responsible for the production of seasonal and district flavours other than the flavour attributed to the essential oil of tea, but no definite information in support of this is available.

Fresh leaf carries a considerable bacterial flora which apparently takes no part in fermentation. Foreign bacteria may be introduced into the fermenting leaf and may give 'taints' to the tea. Fermenting tea leaf may also carry certain moulds, and species of *penicillium*, *aspergillus*, *mucor* and *dematium* have been found.[35]

During the firing of tea the oxidizing enzyme is inactivated, the moisture content of the leaf is reduced to 3 per cent or less, and fermentation practically ceases.

It is convenient here to state what constitutes true fermentation and to describe briefly enzymes, yeasts and bacteria.

Fermentation denotes the decomposition of carbohydrates by yeasts to form alcohol and gas or acid and gas. Although various workers have suggested that true fermentation may go on during tea manufacture since yeasts exist on the leaf and traces of an alcohol are formed when leaf is rolled, by far the main reaction is the oxidization of the tea tannin. The term 'fermentation' in connexion with tea manufacture is essentially a merchants' and planters' expression, but one which custom demands shall be retained. 'Oxidization' is a more fitting term to describe the process under discussion.

Enzymes are substances which bring about chemical changes without undergoing any permanent change themselves. They are organic catalysts. Enzymes occur in all plants and are responsible for reactions in the plant cell which can usually only be brought about with difficulty *in vitro* without their aid.

[35] K. A. R. Bosscha and A. Brzesowsky, *Meed. Proef. Thee*, Buitenzorg (1916), No. 47.

The chemical structure of enzymes is at present unknown and they are classified according to their reactions, which may be hydrolytic, oxidizing, fermenting, etc. The enzyme of interest in tea manufacture is an oxidase, and in oxidizing the tannin in tea leaf it is performing a post-mortem reaction which does not take place in the living cell.

Enzymes are not living bodies and cannot reproduce themselves. They are generally inactivated by temperatures above 140° F.

Unlike enzymes, bacteria are living bodies capable of reproduction. They are minute vegetable organisms, for the most part unicellular and reproducing by fission. Yeasts and moulds, like bacteria, are vegetable organisms but rather more highly developed. All these micro-organisms under favourable conditions reproduce with great rapidity. At certain temperatures they are killed. In their attack on organic matter they often produce substances of characteristic odour or flavour.

The Composition of Tea Leaf and Tea

Fresh tea leaf contains about 75 per cent moisture, although the content may be as low as 70 per cent or as high as 80 per cent. The solid matter of the leaf is thus about one quarter of the total weight. Finished tea contains from 3 to 10 per cent moisture.

The frame of the leaf is made up of cellulose and fibre, which with pure proteins comprise most of the water-insoluble matter of the leaf. Tea tannin, caffeine, protein bodies or proteoses, gummy matter and sugars are other important constituents which, unlike the foregoing, are soluble in water. In addition the leaf contains small quantities of mineral substances, chlorophyll pigments, flavones, anthocyans, waxes and resins, mucilages and pectic bodies, oxalic acid, gallic acid and compounds

of the purine group, which are more or less soluble. All these bodies are present in both black and green teas.

Black tea contains, in addition to the above substances, oxidized tannin products and traces of the tea essential oil. Green tea is devoid of these substances.

When tea leaf is burnt the mineral substances remain as ash. Tea ash consists of about 50 per cent potash and 15 per cent phosphoric acid. The rest is mainly lime and magnesia, with small quantities of iron, manganese, sodium, silica, sulphur and chlorine. The pectinate, oxalate and phosphate of potash have been identified in fresh leaf and in tea.

The approximate constitution of fresh leaf and green tea made from that leaf is the same. Kosai, in his work referred to under,[14] observed a fall in tannin content in fresh leaf from 12·91 per cent to 10·64 per cent in green tea, whilst with black tea the tannin fell to 4·89 per cent. The hot water extract in fresh leaf he found to be

The Composition of Fresh Tea Leaf and Black Tea made therefrom

		Fresh leaf	Black tea
		%	%
Cellulose	insoluble in water	12	12
Crude fibre	insoluble in water	21	21
Pure proteins	insoluble in water	17	16
Starch		0·4	0·2
Tea tannin	soluble in water	22	12
Caffeine	soluble in water	4	4
Gummy matter	soluble in water	3	2
Sugars	soluble in water	1·0	1·5
Soluble minerals (ash)	soluble in water	4	4
Protein bodies	soluble in water	12	13
Oxidized tannin products	soluble in water	nil	2
Chlorophyll pigments		1·5	1
Total ash		5·5	5·5
Tea essential oil		nil	traces

50·97 per cent, in green tea 53·74 per cent and in black tea 47·23 per cent.

The foregoing table shows in some detail the changes in the composition of leaf which occur during black tea manufacture in Assam. The tannin figures differ considerably from those given above, which were obtained with leaf grown in Japan.

The water extractions were made by boiling for one hour. It will be observed that in the table above the tannin falls from 22 per cent to 12 per cent. Some of this tannin reappears as a soluble red body, amounting to 2 per cent in the example under consideration, which accounts for some of the colour in a tea infusion and also for some of the precipitate known as the 'cream' which forms when a tea infusion cools. Most of the tannin which is lost in manufacture is apparently fixed, however, and rendered insoluble by the leaf proteins.

There is a limited change in the pure proteins during manufacture which break down to soluble protein bodies. Slight starch decomposition takes place, and a small increase in sugars.

The table above indicates the nature of the changes taking place and the figures cannot be taken as an average for black teas. For example, tea grown in China, Darjeeling and the high altitudes of Ceylon contains from 15 per cent to 17 per cent tannin in the fresh leaf, whilst the finished tea only contains from 5 per cent to 10 per cent tannin.

Before leaving the subject of the composition of tea, it is of interest to observe the difference between an hour's extract with boiling water and that given by a five-minute infusion. The figures in the next table are of the order of those given by a fine Assam tea, and the tannin, as in the previous table, was estimated by the Loewenthal method.

The Water-soluble Matter in Tea and in a 5-minute infusion

	Total soluble matter boiling 1 hour	Matter soluble 5-minute infusion
	%	%
Tea tannin	12	7
Caffeine	4	3
Protein bodies	12	6
Gummy matter	2	1
Sugars	1·5	1
Soluble minerals	4	2·5
Oxidized tannin products	2	2
Total soluble solids	37·5	23·0

It is worthy of note that the amount of oxidized tannin products extracted by a five-minute infusion is of the same order as that extracted in an hour. This suggests that these substances are mainly on the outside of the leaf and are therefore easily extracted.

The Quality of Tea

In spite of the suggestion made in 1879 by Blyth[12] that the tea taster would eventually be replaced by the analyst, present-day analytical methods are useless for measuring the market value of a tea or for detecting the qualities of a liquor.

The substances responsible for flavour and aroma cannot be estimated by the chemist. Caffeine, one of the few constituents in a tea infusion which the chemist can accurately determine, is not of importance to the taster, since its faintly bitter taste is masked in an ordinary tea infusion. The caffeine content hence has little influence on the market value of a tea except in so far as its presence adds thickness to the liquor.

Apart from flavour and aroma, tea sells mainly for its liquors, although in some markets the appearance of the leaf is of importance. The liquors of India, Ceylon and Java teas should be bright red in colour, thick and pungent. The liquors of China teas are usually much lighter both in body and colour than the foregoing.

Where the appearance of the tea is of importance, 'tip' is valued, and leaf which is well twisted, black in colour, even in grade and free from dust and fannings is usually required in the case of black teas. Inveterate tea drinkers, however, usually judge a tea by the liquor it gives, and do not attach great importance to the style of the leaf.

Many attempts have been made to correlate the taster's description and evaluation of a tea with a chemical analysis of the liquor. The thickness of the liquor is governed by the solids dissolved in it, and the pungency and strength depend on the tannin and tannin products. Hence it would be expected that an estimation of both tannin and solids in an infusion would to some degree be correlated with the qualities and value of the tea.

Estimations of the water-soluble solids, caffeine and tannin extracted by one hour's boiling from many India teas failed to show any significant correlation with the taster's description of the teas, although very good teas could be distinguished from very bad ones by this means. Teas of approximately the same class could not be ranged by these analyses, and the caffeine content could in no way be correlated with quality.

Deuss[36] estimated the caffeine, tannin and solids extracted by a five-minute infusion from many Java, Japan, China and Formosa teas, but failed to correlate these values with the market values of the tea.

[36] J. J. B. Deuss, *L'Agronomie Coloniale*, Paris (Aug. 1924), No. 80.

The table below shows the figures obtained by Deuss and also gives the range of figures usually shown by India black teas. Deuss estimated the tannin by the formaldehyde method, whilst in the case of the India black teas the Loewenthal method, with a conversion factor of 0·0416, was used. It will be noticed that the range of variation is very wide.

Table showing caffeine, tannin and soluble solids extracted by a 5-minute infusion

	Caffeine	Tannin	Soluble solids
	%	%	%
Java black teas	2·7 to 4·4	6 to 20	16 to 26
Japan green teas	2·0 to 3·3	4 to 12	16 to 26
China black teas	2·0 to 3·7	5 to 10	16 to 22
Formosa Oolong teas	3·1 to 3·7	12 to 23	23 to 25
India black teas	2·0 to 3·0	6 to 10	22 to 25

In Ceylon[37] it has been observed that the market values of a series of teas from the same estate follows the tannin content, especially that soluble in acid. When acid is added to a tea infusion some of the tannin is precipitated, and that which remains in solution has been correlated, in the case of certain Ceylon teas, with the quality of the tea. In India no such relationship has been obtained, although when such estimations were carried out they were made on teas taken indiscriminately.

It is understandable that a series of invoices from the same estate, showing the same characteristics should vary in value roughly with the tannin content of the infusion, although when flavour appears or some seasonal change in the character of the tea is registered such a relationship might be expected to break down.

[37] R. V. Norris, *Tea Quarterly*, Colombo (1929), 2, pt. 4, 142.

The failure of the tannin analysis of an infusion to show a close correlation with the liquoring qualities is due to the failure of the analysis to discriminate between the different tannin bodies present. If it were possible to divide the total tannin into a series of products each with a certain degree of pungency or liquoring quality, then no doubt a close correlation between the analysis and the taster's description would be obtained.

The chemist will never replace the tea taster, not only because of the high cost of analysis, even if this were able to discriminate between teas, but also on account of the rapidity with which the taster can work. A tea taster can taste, describe and evaluate a dozen teas in a few minutes.

In Japan green teas can to a great extent be judged by the anthocyan content of the infusion, which substances are absent from the finest teas.[38] This test, described in detail in the chapter dealing with tea in Japan, does not apply to black tea.

Before leaving the subject of the quality of tea in relation to the analysis of its liquors, mention must be made of a paper published anonymously in *The Lancet* in 1911.[39] In this paper it is claimed that much of the tannin in a tea infusion is combined with the caffeine, and that in such combination it is harmless to the human system. It is further assumed that uncombined tea tannin is harmful and is present in greater quantity in poor than in good teas.

The assumption that tea tannin is combined was based on the following observations. If a tea infusion is saturated with ammonium sulphate a precipitate is obtained which contains amongst other things caffeine and tannin, usually in the ratio 1 to 3 by weight. It

[38] C. R. Harler, *Ind. Tea Assn. Quart. Jour.*, Calcutta (1924) pt. 1.

[39] Anonymous, 'The Chemistry, Physiology and Aesthetics of a Cup of Tea,' *The Lancet*, London (1911), January 7th.

was then concluded that a compound in these proportions existed in the infusion. A precipitate containing tannin and caffeine is also obtained when a black tea infusion is treated with acid.

Deuss has prepared caffeine-tea-tannate from caffeine and pure tea tannin in the absence of water, but has shown that it is decomposed by water.[40] This is a normal case of hydrolysis of a compound of a weak acid and weak base.

It is possible that oxidized tea tannin as it occurs in black tea may form a more stable compound with caffeine than does pure tea tannin. This supposition is supported by the fact that no precipitate of caffeine and tannin is obtained when a solution of pure tannin and caffeine is acidified. Again, the extraction of caffeine from green tea, in which most of the tannin is in the unoxidized form, is much more rapid on infusion than it is in the case of black tea in which most of the tannin is oxidized. This suggests the possibility of a compound in the case of dry black tea which must be hydrolysed before the caffeine dissolves.

On the other hand, the presence of a definite compound of caffeine and tannin is rendered doubtful by the fact that the ratio of the quantities precipitated by sulphate of ammonia may vary from 1 to 3 up to 1 to 12 according to the strength of the infusion. This suggests the possibility that the caffeine is carried down with the precipitate of oxidized tannin.

It seems evident that in solution any compound of caffeine and tea tannin will be largely hydrolysed. So far as ordinary black teas are concerned there is no correlation between quality and the amount of caffeine and tannin precipitated either by acids or sulphate of ammonia.

40 Quoted by H. Neuville, *Technologie du Thé,* Paris (1926), 19.

Neither should the possible presence of such a compound be given any weight from the point of view of pharmacology. Any tea tannin with highly developed tannin properties will be precipitated by the caseinogen in the milk before the tea is drunk. Even if tea is taken without milk the oxidized tannin will be precipitated in the acid medium of the stomach with or without proteins according as they are present or not. It would thus appear that the presence of caffeine will have very little effect.

This paper has been dealt with in some detail because it is still frequently quoted by merchants as an argument in favour of certain teas in which it is claimed that the tannin is rendered innocuous because of its combination with caffeine.

Government Examination of Tea

According to the Sale of Food and Drugs Act of 1875, all tea entering the United Kingdom shall be subject to examination by persons appointed by the Commissioners of Customs. If samples are mixed with foreign substances or exhausted leaf, the tea shall not be delivered in the United Kingdom. If, in the opinion of the analyst, tea is unfit for human food, it shall be destroyed or forfeited.

Teas are examined at the Government Laboratories situated in the Customs Department in the City of London. In 1932 the number of samples examined was 26,000, of which 124 failed to pass the tests. Of these, 87 contained foreign substances and 37 were unsound. The actual percentage of tea which is rejected is very small since in most instances individual chests have been damaged and fail to pass the tests.

There are no definite specification tests for tea laid down by the authorities in the United Kingdom, and the decision regarding unfitness rests with the analyst.

The tea is first infused in the manner followed by the tea taster, and the infused leaf examined for smell and colour. A bad tea usually smells mouldy and the infused leaf is often black.

The presence of foreign leaves is detected by a hand lens, and confirmed, if necessary, with a microscope. The veins, serrations, hairs and the shape of the apex of the tea leaf are used as indications, as are also certain of the leaf tissues.

The presence of exhausted tea leaf is judged largely by the total ash and soluble ash in the leaf. The former should be 5·5 per cent to 6·0 per cent, and the latter about 4 per cent of the dry matter of the leaf. The presence of exhausted leaf lowers these values. Of the total ash, all but about 1 per cent or less is soluble in dilute acids, and a much greater figure than this indicates the presence of impurities like sand, in the sample.

At one time impurities added as 'facing' were common in some teas from China and Japan, but little trouble is given in this respect nowadays.

Included in the ordinary tests applied to tea is the passing of a magnet through the sample, to detect the presence of iron filings.

Chapter VI

SOME IMPORTANT CONSTITUENTS OF THE TEA LEAF

The chemistry of tea tannin—Variation in the tannin content of leaf — Caffeine — Nitrogenous compounds — Carbohydrates — Chlorophyll and allied pigments—Waxes and resins.

Much of the matter in this chapter is of academic interest, but nevertheless worth recording. The second section of the chapter, dealing with the variation in the tannin content of the leaf, is of considerable practical interest to the tea planter in North-East India. Most of the teas from this area are valued on account of their liquoring qualities which, in turn, are governed by the tannin content of the plucked leaf. It is therefore of interest to know which conditions favour a high and which a low tannin content. With such knowledge, it will be understood why care in plucking and manufacture may not always result in good liquoring teas.

The Chemistry of Tea Tannin

Tea tannin has received more study than any of the other constituents of the tea leaf. Flavour, although the most highly valued quality of black tea, is evanescent and beyond control. In addition the flavour producing substances are present in minute quantities which make examination difficult. On the other hand, tea tannin occurs in large quantities in all tea leaf and, according to manipulation, can be turned to good account or otherwise. Tea tannin and its products are responsible for the pungency and colour of a black tea infusion, and

also account in part for the strength and thickness of the liquors.

In the discussion on tea tannin, the preparation and properties of the substance are first described. Then follows an account of some of the changes to which tannin is subject.

Preparation and properties of tea tannin. Tea tannin may be prepared from fresh or withered leaf or tea or from water extractions of any of these.

Deuss[18] obtained tea tannin from leaf as follows. The leaf is dried at a 100° C. and then extracted with warm benzene to remove waxes, chlorophyll, etc. The leaf is next extracted with alcohol, which removes the tannin and other substances, and the extract concentrated to a syrupy mass and then poured into water, whereby certain substances are precipitated and the tannin dissolved. The water solution is agitated with ether to remove any gallic acid present, and then extracted with ethyl acetate which dissolves the tannin. The tannin solution is dried over sodium sulphate and then poured into dry chloroform which precipitates the tannin. The precipitate is filtered and dried *in vacuo*. The product is a white or faintly yellowish powder.

The yield given by this method is only about 10 per cent of the total tannin in the leaf, the loss occurring during the salting out process which is necessary before extracting with ethyl acetate, otherwise a very impure product is obtained. When tea is used instead of leaf in the above preparation, a brownish tannin is obtained which is very difficult to purify.

Tea tannin in a state approaching purity may be obtained from a fresh leaf infusion by the following method. The infusion is first extracted with benzene to remove gummy and resinous matter, then extracted with ether to remove gallic acid, which occurs in small

quantities in tea leaf. The infusion is next extracted with ethyl acetate and most of the tannin thus removed. The ethyl acetate solution is dried over sodium sulphate and the tannin precipitated with chloroform.

Tannin thus prepared may be from 85 per cent to 95 per cent pure. When estimated by the Loewenthal process,[40] tea tannin is found to require a factor of 0·0416 to convert each c.cm. of normal permanganate used in oxidization to the weight of tannin obtained by the standard hide powder method.

When the tannin in fresh leaf or withered leaf infusions is estimated by the Loewenthal method the same conversion factor, 0·0416, serves. With oxidized tea tannin and the tannins present in a black tea infusion a different factor is required, an important point reverted to later.

The properties of tea tannin may now be considered. It is instructive to describe some of the properties of tannins in general and to indicate how tea tannin compares with the ordinary tannins of its class.

1. Tannins are mostly uncrystallizable, colloidal substances, soluble in water, slightly acidic and showing astringent properties.

Tea tannin has a pH value of 4·4. When the solution is taken in the mouth it gives a bitter taste rather than the sensation of astringency or pungency. Tea tannin only develops marked pungency on oxidization.

2. Tannins form blackish-blue or blackish-green compounds with iron salts, these compounds having been originally used as inks.

With neutral ferric chloride solution, tea tannin gives a dark blue coloration.

[40] 'Procter's modification of Loewenthal's method,' *U.S. Dept. Agric. Dept. Chem.*, Washington, Bull. No. 13, pt. 7, 80.

3. Tannins precipitate gelatine from solution and form insoluble compounds with gelatine-yielding tissue, a property which enables them to convert hide into leather.

Tea tannin only precipitates gelatine from a concentrated solution, and the precipitate is decomposed on dilution. Tea tannin is thus a pseudo-tannin or false tannin. On oxidization the tanning properties of tea tannin are enhanced and the compound formed with gelatine is able to withstand decomposition by water. This aspect of the subject will be further developed in the chapter dealing with the pharmacology of tea.

4. Tannins precipitate alkaloids and substances of a basic nature.

Tea tannin precipitates some alkaloids and in this respect its reaction with caffeine is of interest. As previously denoted caffeine-tea-tannate is decomposed by water, but there is some indication that the compound of oxidized tea tannin and caffeine is not so readily hydrolysed.

5. In alkaline solution the tannins and many of their derivatives readily absorb oxygen, becoming dark in colour.

This property is shown by tea tannin. The expressed juices of the tea leaf are acid, showing a pH value varying from 4·6 to 5·2. These juices are readily oxidized by the aid of the enzyme present, but if the juice is heated to about 160° F. and the enzyme inactivated no appreciable oxidization takes place for many weeks provided the solution is kept in the dark.

6. In acid solution the catechol tannins produce insoluble red substances known as phlobaphenes or ‘ reds ’.

Tea tannin is a catechol tannin and forms phlobaphenes.

It is now proposed to discuss the condensation and oxidization products of tea tannin formed both *in vitro* and *in vivo*, together with the power of these products to precipitate proteins.

Condensation and Oxidization Products of Tea Tannin formed in vitro. When tea tannin is boiled with 5 per cent sulphuric acid a series of condensation products is obtained, showing different degrees of solubility. Most of the substances so formed are insoluble in water, and after about thirty-six hours' boiling a product insoluble in alkalies, alcohol and the commoner solvents is obtained. These products can be formed in the absence of air. In appearance they are dark brown powders.

In alkaline solution and in the presence of air, tea tannin forms a series of oxidization products. Very full oxidization leads to the formation of substances which are insoluble in water and have lost all their tannin value. All the tannin products formed in alkaline solution are soluble in alkalies and alcohol.

The oxidization products are mostly precipitated from solution by acid, if they are present in sufficient concentration. If, however, during oxidization the alkaline solution has a pH value greater than 10, then the tannin products formed are not precipitated by acids.

Both the condensation and oxidization products of tannins which are insoluble in water are included in the group of substances called phlobaphenes.

It is not known whether the phlobaphenes formed from tea tannin *in vitro* by the methods described above are also formed during the manufacture of black tea, but oxidization products are formed during fermentation and under certain conditions of manufacture condensation products can be formed.

Condensation of Tannin in Tea Leaf. In the living tea leaf tannin can undergo rapid condensation under the influence of heat.

If leaf is heated to about 150° F. it begins to redden in about ten minutes, whilst at lower temperatures the reddening takes longer to start. This change takes place equally well *in vacuo* as in air, indicating that the tannin has undergone condensation and not oxidization. At temperatures below 90° F. it takes many hours for the leaf to redden, unless it is withered, in which case reddening begins after about 6 hours at 90° F. The reddening of tea leaf is accompanied by a loss in soluble tannin.

If tea leaf is heated to 160° F. the leaf enzymes are inactivated, and after such treatment no rapid change in the tannin takes place and the leaf can be kept for long periods without any appreciable alteration in colour or soluble tannin content.

From the evidence it may thus be concluded that when warmed tea leaf turns red it does so because of the condensation of the tea tannin and that this change is assisted by leaf enzymes.

If leaf is heated to 160° F. and then rolled, and the juice exposed to the air as in the manufacture of green tea, it becomes dark in colour and some of the soluble tannin is lost. This change is likely to be due to the formation of oxidization products of tannin, since exposure to the air is necessary for the change to take place.

When 'red leaf' is infused, the infusion is red and the infused leaf is a dull blackish-green, similar to that of exhausted tea. Extraction of the infused leaf with alcohol fails to remove the colour, suggesting either that a condensation product which is insoluble in alcohol has been made, or that the colour of the leaf is due to something else, possibly a compound formed by leaf proteins and condensed tannin.

In practice the formation of 'red leaf' is common. Leaf packed in a basket rapidly heats up and temperatures in the bulk of well over 110° F. are frequent. The tannin loss due to reddening may be great and cases are common in which fresh leaf containing about 22 per cent tannin when plucked only contains about 17 per cent on reaching the factory. 'Red leaf' when manufactured makes poor tea with thin liquors and dull infusions.

Oxidization of Tannin in the Leaf. When tea leaf is crushed and the juice exposed to the air it instantly turns red, oxygen is absorbed and the soluble tannin content of the leaf decreases. If leaf is crushed *in vacuo* it remains green and there is no change in the soluble tannin content. Leaf which has been killed by heating to 160° F. can be rolled in air with only a small loss in tannin and no appreciable reddening.

The rate of oxygen absorption is rapid when the leaf is first crushed, but slows off after 3 or 4 hours and then becomes very slight. As the oxygen absorption proceeds the soluble tannin in the leaf decreases. Details of these changes are given later, but at present an attempt will be made to indicate the manner in which the tannin becomes insoluble during the fermentation of tea leaf. Before doing this, something must be said on the subject of the estimation of tea tannin and its soluble products.

There is no difference between the tannin content of fresh and withered leaf as estimated by the hide powder and Loewenthal processes.

As soon as fermentation begins and oxidized tannin bodies are formed, the Loewenthal process when used with a conversion factor of 0·0416 gives lower values than the hide powder method. Each infusion requires its own factor to suit the mixture of tannin and tannin products it contains. Conversion factors varying from

0·055 to 0·070 have been found necessary to make the Loewenthal value tally with the hide powder figure.

The hide powder method of estimating the total tannin also fails to give a true value with most fine India tea infusions for the following reasons. In this estimation it is essential that the solution be clear to transmitted and reflected light, and shall contain between 0·375 and 0·425 gm. tannin per 100 c.cm.[41] The normal India tea infusion is not clear on cooling, and after filtering to clearness the resultant solution generally contains only about 0·25 gm. tannin per 100 c.cm. Dilution below the strength required by the standard conditions of the hide powder method gives tannin values which are too high.

Thus, the true value of the tannin content of a clear tea infusion of a fine black India tea is somewhere between the value given by the Loewenthal method using a conversion factor of 0·0416, and the hide powder method carried out on the strongest clear solution obtainable.

During fermentation a whole series of tannin oxidization products is apparently formed, and some of the tannin is not oxidized at all, as is evidenced by the fact that tea tannin as a whitish powder can be extracted in small quantities from black tea by either of the processes already detailed. Evidence of the presence of unoxidized tannin is also given by the fact that when dry tea is extracted with dry alcohol about 1 per cent to 3 per cent of tannin is removed, whilst the rest of the soluble tannin can only be extracted when water is present. It is probable that the tannin extracted by dry alcohol is unoxidized, although the arguments supporting this assumption are too lengthy to be detailed here.

The presence of various groups of tannin products in a tea infusion is indicated by the following observations.

[41] This is the standard adopted by the American Leather Chemists Assn., *J. Am. Leather Chem. Assn.* (1931), 16, 113.

When a tea infusion is allowed to cool a precipitate spoken of as the 'cream' separates. On filtering off the 'cream' there is observed to be only a small loss in the tannin content of the filtrate as estimated by the Loewenthal method, using a conversion factor of 0·0416. The 'cream' contains only a very small percentage of nitrogenous compounds and consists mainly of tannin products. These must either need a very high Loewenthal conversion factor or be near phlobaphenes which are soluble in warm tannin solution.

When acid is added to a tea infusion made of the strength used by the tea taster, about half the tannin is precipitated. More is precipitated from stronger infusions. When gelatine solution is added to a tea taster's infusion of India tea, usually more than half the tannin is precipitated. The solution remaining after the action of either acid or gelatine is still strongly coloured, showing that tannin products remain in solution.

Such reactions may be explained by assuming that tannin is present in different stages of oxidization or condensation. Indeed, some such assumption is necessary to explain why two infusions with the same tannin content, as estimated by the Loewenthal or hide powder processes, are so differently reported on regarding liquoring qualities by the tea taster.

The Precipitation of Tea Tannin by Proteins. It has already been stated that tea tannin, in its pure form, is a pseudo-tannin unable to precipitate gelatine or protein except from concentrated solutions. When tea tannin is oxidized, as in the fermentation process of black tea manufacture, the product has an increased tanning power over the pure tannin. In a black tea infusion about a half to three-quarters of the tannin is precipitable by gelatine in a form which is not decomposed on dilution.

Tea leaf contains more than 15 per cent proteins which have the power to precipitate tannins. It is hence of interest to observe how far these substances react with the tannin and tannin products in tea leaf during tea manufacture.

If tea leaf is crushed *in vacuo* and allowed to remain 3½ hours, the normal time for fermentation, and then dried *in vacuo*, the 'tea' thus made shows the same water-soluble tannin as the original leaf, and the leaf itself resembles in colour that of freshly dried leaf. It can hence be assumed that unoxidized tea tannin does not precipitate proteins in the leaf.

Fresh tea leaf as grown in Assam contains about 20 per cent tannin, and the manufactured black tea about 12 per cent, this latter figure being between the values given by the Loewenthal and hide powder methods of estimation. The tannin products included in what is known as the 'cream' equal about a tenth of the original tannin in leaf which makes a good tea. Thus the 'cream' may amount to 2 per cent tannin, and the total weight of water-soluble tannin and its products accounted for is thus about 14 per cent.

It is still necessary to account for about 6 per cent tannin which remains in the leaf. This is present either as water-insoluble condensation or oxidization products, i.e. phlobaphenes, or combined with leaf proteins in the form of leather-like substances. Evidence, as detailed below, suggests the latter, and it would appear that the blackish-green colour of spent tea which has been exhaustively extracted with boiling water is due mainly to the presence of a compound of oxidized tannin and leaf proteins.

It will be remembered that the only phlobaphene formed from tea tannin *in vitro* which is insoluble in ordinary solvents and in alkalies, is the condensed product

obtained by boiling tannin with 5 per cent sulphuric acid for many hours. The extraction of spent tea with alcohol gives a green solution, so coloured by chlorophyll, but no coloured tannin bodies. Extraction with ethyl acetate or acetone also fails to give any coloured tannin body. Extraction with alkali gives a deep red solution which throws a bulky precipitate on acidification. The leaf residue after this last treatment is a yellowish-grey mass.

Whilst it is possible that leaf enzymes may have formed some phlobaphene which is soluble in alkali and insoluble in acids and the other solvents, it is far more likely that, as indicated above, a compound of oxidized tea tannin and leaf protein exists in black tea. Such a compound would be decomposed by alkalies and the tannin product so liberated would be precipitable by acids.

Variation in the Tannin Content of Leaf

Since the liquoring qualities of many black teas are dependent largely on the tannin and tannin products in the infusion, the importance of the amount of tannin in the original leaf will be appreciated. It may be anticipated that leaf rich in tannin will give tea with good liquors. It may here be remarked that some of the finest black teas, valued on account of their flavour, contain very little soluble tannin. In the development of such flavour methods are often used which happen to lead to the very full oxidization and subsequent precipitation of most of the tea tannin. Fresh tea leaf, however, which gives the finest black tea, is always richer in tannin than leaf from the same district at the same time which gives poor teas, although the fine finished tea may contain less tannin than the poor finished tea.

An analysis of good leaf and poor leaf reveals how great may be the difference in tannin between leaf samples.

YOUNG TEA SHOOTS GROWING FROM ONE YEAR OLD WOOD

By permission of the Indian Tea Association

The table below shows not only the tannin but also the caffeine and water-soluble solids in soft, succulent young leaf plucked in Assam, and of poor leaf which was harder and dryer, being plucked in an unfavourable part of the season, but still young. The samples were extracted for one hour in boiling water and the percentages are calculated on the dry matter in the leaf.

	Good leaf	Poor leaf
	%	%
Tannin	25	15
Caffeine	4	2
Soluble solids	49	35

There is a wide variation in the tannin content of various parts of the shoot. The wood and roots contain about 1 per cent tannin and the seeds a trace. Most of the tannin is located in the leaves and the following table was obtained from the analysis of shoots plucked in mid-season in Assam.

	Percentage	
Bud	29·8	tannin
First leaf	29·9	,,
Second leaf	21·3	,,
Third leaf	17·8	,,
Fourth leaf	14·5	,,
Upper stalk	11·7	,,
Lower stalk	6·4	,,

In the plains of India, Ceylon and Java the tea shoot contains about 20 per cent tannin. In the elevated districts the value is much lower, maybe about 17 per cent. In China and Japan a normal shoot contains about 15 per cent tannin.

The type of plucking, as well as the coarseness, influences the amount of tannin in the leaf. *Banjhi* (dormant) shoots or shoots plucked from tea seed bushes

contain less tannin than leaf from normal plucking bushes. In the month of July the following figures were obtained in Assam.

	Percentage
Normal plucking shoots ..	20·13 tannin
Shoots from tea seed trees ..	16·14 ,,
Banjhi (dormant) shoots ..	13·06 ,,

The length of the plucking has a very definite influence on the tannin content of the shoot. In one season in Assam it was observed that bushes pruned to 9 inches and plucked at 36 gave leaf with an average tannin content of 22·7 per cent. Similar tea, pruned at 30 inches and plucked at 36, gave leaf with an average tannin content of 24·2 per cent. It is generally recognized amongst planters in Assam that close plucking gives stronger liquoring teas than long plucking, assuming the leaf to be equally fine in both cases.

There is no appreciable difference between the tannin content of leaf from bushes of different varieties grown under the same conditions. In Assam leaf plucked in June from bushes of the Burma, Assam and China varieties showed the following tannin contents, which are all well within the error due to sampling.

	Percentage
Shoots of Burma variety ..	21·09 tannin
Shoots of Assam variety ..	20·89 ,,
Shoots of China variety ..	21·15 ,,

In North-East India the tannin content of the shoot is constantly changing throughout the season. Early in the season (March and April) it is low in the 'tippings' from pruned tea. In May it increases rapidly and usually touches 25 per cent in the shoot and it is during this period of the second flush that the finest teas are made, having both flavour and cup quality. From May on, the tannin content fluctuates between 18 and 22 per cent, a period of high tannin content coinciding with good

liquoring teas and one of low tannin content with poor liquors.

The following values are typical of the fluctuations recorded in Assam.

				Percentage	
March	25th	shoots	contain	15·50	tannin
April	26th	,,	,,	17·91	,,
May	10th	,,	,,	24·59	,,
May	17th	,,	,,	22·72	,,
June	7th	,,	,,	19·73	,,
July	12th	,,	,,	21·12	,,
August	9th	,,	,,	18·98	,,
August	30th	,,	,,	21·14	,,
October	4th	,,	,,	20·61	,,

So far no obvious correlation has been found between these tannin changes and either the crop curve or climatic conditions such as sunshine, rainfall and temperature.

The tannin in the shoot varies according to the growing phase in which the shoot happens to be. Thus, a shoot plucked just before it goes *banjhi* is poor in tannin, and the 'tippings' which are largely composed of such shoots constitute poor leaf on this account. A shoot plucked from growth which has gone *banjhi* and subsequently grown again has a very high tannin content if plucked just above the new *janum*. It will be understood that as the season progresses, shoots originating from axils below the plucking table may, when plucked, be in a phase when the tannin is high or in one when it is low. It is thus possible to explain the frequent fluctuations by supposing that the majority of the shoots happen at one time to be in one growing phase or the other just described.

In North-East India it is common knowledge that the liquors of the manufactured tea vary in thickness and brightness from week to week. In the few cases where the necessary observations have been made, these changes

have been correlated with the fluctuations in the tannin content of the leaf.

In Japan,[26] and the Caucasus[42] where, as in Assam, the flush ceases in the cold weather, the first pluckings are poorer in tannin than the later ones. In Java, where there is no close season and the bushes are plucked the whole year, the flushes following the pruning are poorer in tannin than those plucked after the bush is in its full season.[43] In Ceylon it has been recorded on a high-grown estate that 5 months from pruning the tannin content of the shoot was 14·4 per cent, 16 months from pruning it was 18·7 per cent, and 34 months from pruning it was 17·3 per cent.[16]

Bamber, in Ceylon, showed that the leaves of the tea bush exposed to the sun contained more tannin than inner leaves not so exposed.[16] Hope, in Assam, showed that bushes shaded either by grass or trees gave leaf with a smaller tannin content than that plucked from unshaded bushes.[44] Shade affects the quality of tea, and in Assam it has been found that bushes grown under heavy shade give poorer teas with lighter liquors than bushes which are unshaded or lightly shaded.

In the Uji district of Japan it is customary to place dense grass shading over the bushes for about three weeks before the first flush producing the fine Gyo Kuro teas. This shade reduces the anthocyan content of the leaf and improves the quality of the tea. It has also been observed that such shading reduces the tannin content of the leaf by as much as 3 per cent.

The amount of tannin in the shoot is affected by certain manuring, and in Assam a dose of nitrogenous manure giving 120 lb. nitrogen per acre very definitely

[42] J. Galy-Carles, *Rev. App. Bot. Agric. Coll.*, Paris (1928), Bull. 86, 683.

[43] J. J. B. Deuss, *Arch. Theecultuure*, Batavia (1928), 1, pt. 4, 123.

[44] G. D. Hope, 'Experiments in the Quality of Tea,' Ind. Tea Assn., Calcutta (1910).

lowers the tannin content. Normal doses, i.e. 30 to 40 lb. nitrogen per acre, have no such marked effect and may even produce leaf richer in tannin than that obtained from unmanured, poor tea.

In North-East India all observations go to show that anything that reduces the tannin content of the shoot, e.g. coarse leaf, long plucking, dense shade or heavy nitrogenous manuring, reduces the cup quality of the tea.

Caffeine

The alkaloid caffeine was first discovered in coffee in 1820. It was found in tea in 1827, and called theine. Later it was shown that caffeine and theine were identical and the latter term was then discarded. Caffeine also occurs in maté and various other plants.

Pure caffeine forms long, white, silky needles of hexagonal shape, which make a light fleecy mass. On heating to 120° C. (248° F.) it forms a vapour which settles on cool surfaces. This process is called sublimation and finishes at a temperature of 178° C. Caffeine melts at 234° C.

The constitution of caffeine has been worked out and its properties are known. It is a weak base and forms unstable salts with acids.

There is a demand for caffeine for medicinal purposes and for use in certain drinks. Caffeine for commercial uses is extracted from damaged tea and tea waste as follows. The tea is moistened with about 25 per cent of its weight with water, and then extracted with benzol or toluol. The extract is then distilled with a small quantity of water, and the hydrocarbon thus passes off, leaving the caffeine in solution from which it may be crystallized. The first crystallization gives a product 95 per cent pure, and if the process is repeated three times, the last with animal charcoal, a pure product is obtained.

The yield varies from 2½ per cent to 3 per cent of the waste treated.

The state in which caffeine exists in the leaf has not yet been settled, neither has its natural role in the metabolism of the plant been decided.

The caffeine content of the various parts of the plant has been studied and found to vary widely. The following observations were made in Java.

Part of Plant	Caffeine
	%
First and second leaves	3·34
Fifth and sixth leaves	1·5
Stalk between fifth and sixth leaves	0·5
Tea flowers	0·8
Shell of green fruit	0·6
Seed	nil
Hairs of young leaves	2·25

In both Java and Japan it has been shown that the caffeine content of the leaf is fairly constant throughout the season, but is generally greatest in the pluckings following on pruning. In Japan it has been shown that shading increases the tannin content of the leaf.

Although the caffeine content of the tea leaf does not change during manufacture, many suggestions have been put forward regarding the formation of caffeine complexes with tannin during the processes involved in tea making. Whatever complex may exist in dry tea it is likely that in an infusion the caffeine is practically free. This subject has been dealt with in the previous chapter.

Nitrogenous Compounds

The nitrogen content of the tea shoot consisting of two leaves and a bud varies between 4·75 per cent and 6 per cent of the dry matter, with an average value of about 5·5 per cent.

The caffeine content of shoots plucked in Assam is about 4 per cent. This percentage of caffeine accounts for about a fifth of the total average nitrogen in the leaf, leaving about 4·4 per cent nitrogen in the form of protein and protein bodies. On using a conversion factor of 5·86 for calculating protein from nitrogen, it will be seen that what is termed 'crude' protein averages about 28·5 per cent of the leaf. The nitrogenous compounds in the leaf insoluble in a mixture of alcohol and 2 per cent acetic acid, contain nitrogen equivalent to about 3 per cent of the dry matter. Thus about 17·6 per cent of the dry matter of the leaf may be reckoned as 'pure' protein.

In Japan the quality of green tea varies as the nitrogen content of the leaf, and heavy doses of nitrogenous manures increase the nitrogen in the leaf and improve the quality of the tea.[45] In Assam, a dose of nitrogenous manure supplying 75 lb. nitrogen per acre raised the nitrogen content of tea shoots from 5·37 per cent to 5·96 per cent after three annual applications. No improvement in the quality of black tea has been observed to result from such manuring.

Observations made in Assam show that nitrogenous manuring produces no appreciable increase in the caffeine content of the leaf. Hence it may be concluded that any increase in the nitrogen content following on manuring is due mainly to an increase in leaf proteins and proteoses.

The extraction of proteins from tea leaf in a soluble form is not practicable by methods used for ordinary leaves, either because the crushing necessary for such extraction oxidizes the tannin and precipitates the proteins or because the acidity of the leaf juice is so great that the proteins are coagulated. Whatever the reason,

[45] C. R. Harler, *Ind. Tea Assn. Quart. Journ.* (1924), part 1, 34.

the usual methods employed for protein extraction from plants only give traces of these bodies when applied to tea leaves.

The nature of the proteins in tea leaf and in tea may be determined by the following method. The substance is first extracted with alcohol and 2 per cent acetic acid, and then with water. The residue of the leaf consisting of proteins, cellulose, crude fibre and starchy substances is then examined by van Slyke's method for determining the distribution of nitrogen in proteins.[46] The following results were obtained in Assam when fresh leaf and the tea made from a similar sample of leaf were examined in this manner.

	Fresh leaf	Tea
	%	%
Amide N	2·69	2·75
Humin N	2·86	2·95
Arginine N	9·72	9·01
Histidine N	7·76	8·16
Cystine N	0·60	0·50
Lysine N	6·59	7·95
Mon-amino N	49·99	48·66
Non-amino N	15·28	15·14

The nitrogen distribution is similar to that in several other vegetable proteins, the figures of which are available. The distribution in both fresh leaf and tea is seen to be approximately the same.

During the withering and fermentation of the tea leaf the soluble nitrogenous compounds increase slightly, with a corresponding decrease in the pure protein content. It is common for the total soluble nitrogen to increase from about 2·5 per cent to 2·6 per cent during withering and to 2·7 per cent during fermentation.

[46] D. D. van Slyke, *Jour. Bio. Chem.* (1911), 9, 185, and subsequent papers.

CARBOHYDRATES

The carbohydrates in tea leaf include what is known as 'crude fibre', cellulose, starches, gummy matter and sugars.

The crude fibre and cellulose contents increase from the tender leaf bud to the tougher leaves and stalk. Shoots plucked in Assam in June gave the following results on analysis.

	'Crude fibre'	Cellulose
	%	%
Leaf-bud	12·8	6·5
First leaf	15·0	8·0
Second leaf	16·0	9·4
Stalk	25·3	14·6

Both the crude fibre and cellulose contents of the shoot increase as the season advances. The results below were recorded in Assam in the season of 1929.

Month	'Crude fibre'	Cellulose
	%	%
March	15·4	8·7
April	18·3	11·1
May	22·4	13·6
June	22·5	13·4
July	22·6	13·5
August	24·0	14·0
September	24·8	14·3
October	28·7	17·2
November	30·1	18·0

Old leaves plucked in April which had grown during the previous year showed a crude fibre content of 28·0 per cent and a cellulose content of 16·7 per cent.

Leaf which is growing slowly, e.g. from a seed tree not in plucking, and *banjhi* (dormant) leaf contains more crude fibre and cellulose than quickly growing leaf taken from ordinary plucking bushes.

	'Crude fibre'	Cellulose
	%	%
Shoots from bush in plucking	21.9	13.0
Shoots from tea seed tree	25.7	15.6
Dormant shoots	29.6	17.3

No appreciable change in the crude fibre and cellulose contents of the leaf has been observed during manufacture.

The starch content of the leaf shows considerable variation. It is greatest in dormant shoots and in those which are growing slowly, and least in quickly growing shoots.

Starch is unevenly distributed throughout the shoot, and the values which follow indicate what range may be expected.

	Starch
	%
Leaf-bud	0·11
First leaf	0·19
Second leaf	0·30
Stalk	0·88

The starch content of the shoot varies during the day, being smallest in the morning, when it is about 0·4 per cent, and greatest in the evening, when it is about 0·7 per cent. Leaf plucked throughout the season in Assam at the same time in the morning showed very little

variation in the starch content, the figure ranging from 0·40 per cent to 0·45 per cent.

During manufacture the starch content shows a very definite decrease. In withering a fall from 0·4 per cent to 0·25 per cent is common. During fermentation, a short period of time compared with that of withering, the decrease in starch is very small.

The water-soluble gummy matter in the leaf, precipitated from solution by alcohol, shows some increase during the day. In the average shoot as plucked in Assam these substances vary from 3 per cent to 5 per cent of the dry matter of the leaf.

During manufacture the water-soluble gummy matter decreases appreciably. In a typical case recorded in Assam these substances fell from 3·62 per cent to 2·72 per cent during withering, remained practically stationary during fermentation, and fell to 2·03 per cent in firing.

The sugars in tea leaf have received some study and reference to specific sugars present has already been made.

During the manufacture of black tea the total sugar in the leaf shows a decrease, the main change being registered during withering. In a typical case recorded in Assam, the total sugar content of fresh leaf was 0·84 per cent. During withering this increased to 1·23 per cent, and during fermentation to 1·41 per cent, at approximately which figure it remained during firing.

Chlorophyll and Allied Pigments

Analyses showing the total chlorophyll content of tea leaf have been published, and results vary widely. The values given below were obtained in Assam and include both the chlorophylls *a* and *b* and the pigments carotin and xanthophyll. The estimations were based

on methods outlined by Guthrie.[47] The following results were obtained from fresh leaf and from tea made of similar leaf.

	Fresh leaf	Tea
	%	%
Chlorophyll *a*	0·57	0·30
Chlorophyll *b*	0·25	0·041
Carotin	0·064	0·053
Xanthophyll	0·092	0·013

Thus during manufacture the chlorophylls and allied pigments in the case under consideration decreased from 0·976 per cent to 0·407 per cent. Values widely divergent of these have been obtained, but all estimations agree in showing a falling off in the total pigments during manufacture to less than half that in the fresh leaf.

When fresh leaf is boiled with water its colour changes to a yellowish-green, a change due to a modification in the chlorophyll. Chlorophyll does not contribute appreciably to the colour of dry black tea, for on extraction with acetone or alcohol the tea is, on drying again, visibly indistinguishable from untreated tea. It would thus seem that chlorophyll is only of academic interest so far as black tea is concerned.

Reference to other pigments, flavones and anthocyans, has been made in an earlier chapter.

Waxes and Resins

Estimations of fats and waxes in tea carried out by earlier workers in tea chemistry give contents varying from 3 per cent to 7 per cent. The methods are not usually described but it seems likely that these values include substances besides fats and waxes.

47 J. D. Guthrie, *Am. Jour. Bot.* (1929), 16, No. 9, 716.

The extraction of carefully dried leaf or tea with dry benzene gives substances which may be considered to be mainly fats, waxes and resins. When such an extract is hydrolysed with caustic potash, no glycerol is detected, indicating the absence of an appreciable quantity of fats.

Analyses of leaf and tea which have been carried out in Assam show the waxes and resins in fresh tea leaf to vary from about 1·4 per cent to 1·8 per cent, and in black tea from 0·5 per cent to 0·8 per cent.

CHAPTER VII

CHANGES OCCURRING DURING TEA MANUFACTURE

The withering process—Rolling—Fermentation—Firing or drying—China and India black teas—Green tea.

THIS chapter deals mainly with the changes occurring during the manufacture of black tea as carried out in India, Ceylon and Java. Scientific details regarding the changes taking place under the system of manufacture followed in China are not available, although the type of change which takes place can be anticipated. This is done in the last section but one of the present chapter.

The changes which take place in green tea manufacture are slight, and are dealt with briefly in this chapter and again referred to in a later one describing tea in Japan.

THE WITHERING PROCESS

The principal chemical changes which take place during withering are summarized below. So far as can be seen, none of these changes are of importance, and it is probable that the need for withering largely depends on physical changes which occur to the leaf colloids when the leaf dries.

During withering the main chemical changes are those connected with the carbohydrates. As detailed in the last chapter, the starch and soluble gums decrease and the sugars increase.

The respiration of the leaf continues throughout withering, whereby roughly equal volumes of oxygen are absorbed and carbon-dioxide given out. The resultant loss may amount to 5 per cent of the weight of the dry matter in the fresh leaf.

During withering the water-soluble nitrogenous compounds increase, and over a period of 18 hours this increase may amount to 0·5 per cent of the dry matter in the leaf.

Correctly withered leaf shows the same tannin content as fresh leaf when the method of manufacture is that followed in India. In China, where the leaf is often allowed to redden in withering, there will be some decrease in soluble tannin.

Leaf withered at temperatures higher than about 90° F. turns red, whilst that withered too rapidly or over-withered turns black. In both cases there is a loss in soluble tannin owing to the formation of tannin compounds which are themselves insoluble or are rendered insoluble by proteins in the leaf.

During withering the leaf develops a sweet, fruity odour.

The water extract of both fresh and withered leaf is pale yellow in colour, the yellowness being due to quercitrin. The taste of the liquor from fresh leaf is bitter, whilst that from withered leaf has developed some sweetness although the bitterness of the unoxidized tannin is still apparent.

The obvious change in withering is the loss of moisture from the shoot. Water is lost most readily from the leaves and least readily from the stalk and buds, and it thus happens that if a shoot is dried very rapidly the leaves may become shrivelled and blackened, whilst the bud and stalk remain turgid. Slow withering gives time for the translocation of water from the more to the less turgid parts of the shoot, and in this manner an even wither is obtained.

The necessity for reasonably slow withering is well known in practice. Indeed, under rains conditions in Assam it is often impossible to wither in the open in less

than 24 hours. Under good natural or controlled conditions it is not usual to wither in less than about 8 hours and then the teas tend to show thin liquors. The ideal withering period is governed by the type of leaf being treated and the kind of tea being made. Under conditions in North-East India and Ceylon, the leaf at flavour periods requires a quick wither, whilst at other times, when marked flavour is absent, it is preferable to make for liquors and, on this account, to wither slowly. This subject is referred to again later.

The following table shows the effect of very rapid and of slow withering on the distribution of moisture throughout the shoot. The first column shows the percentage of moisture in the leaves, stalk and bud before withering begins, whilst the second and third columns show the distribution after a rapid wither in 2 hours and a slow one in 24 hours. In both cases the whole shoot was withered to approximately the same degree.

	Fresh leaf	Leaf withered in 2 hours	Leaf withered in 24 hours
	moisture %	moisture %	moisture %
Leaf-bud	78·3	71·1	65·2
First leaf	76·3	60·6	64·0
Second leaf	76·2	55·8	65·8
Stalk	84·7	79·2	73·0
Whole shoot	79·4	67·8	67·3

Tea made from under withered leaf gives infusions often described as thin in liquor and lacking in strength. The infusions also lack pungency and taste bitter, a characteristic described as raw, harsh or rasping. Well withered leaf, if manufactured correctly, gives liquors

with all the possible thickness, strength and pungency which the leaf is capable of developing.

When the liquors of two teas of the extreme types just mentioned are analysed for tannin content and total water-soluble solids, they may show no appreciable difference, a fact which illustrates the shortcomings of present methods of analysis when applied to a tea infusion as a means of assessing the qualities of the liquor.

Another difference, and a very important one, between teas made from well-withered and under-withered leaf is that the former have the pleasant tea aroma well developed, whilst the latter usually have much less aroma. The term aroma is used here to denote that occurring in all black tea, presumably due to the tea essential oil, and not the aroma peculiar to certain districts and seasons. This latter is apparently due to substances other than the tea essential oil.

Rolling

Fermentation begins as soon as the leaf is broken in the rollers. The changes which constitute fermentation will be dealt with in the next section.

The fermentation of tea leaf is accompanied by the evolution of heat and this, combined with the heat evolved by the leaf kept under pressure in bulk, results in a rise in temperature in the roller to between 90° and 100° F. Such high temperatures tend to produce insoluble condensed tannin products in the leaf, and leaf which is allowed to heat up unduly in the rollers may, on this account, produce teas which lack thickness and pungency.

During rolling in a big mechanical roller taking up to 400 lb. leaf, the air supply to the bulk of the leaf is restricted and oxidization is not very rapid. At the same

time the leaf forms into balls which ferment on the outside and remain greenish inside. Accordingly, after about half-an-hour's rolling, the leaf is taken from the roller and put through a coarse-mesh sieve either of the rotary or reciprocating type. This cools the bulk, breaks the balls and at the same time aerates the leaf and aids oxidization. Green sifting takes place after each roll.

After aeration the leaf is put back into the roller and rolled again, by which means more juice is expressed and further oxidization takes place. It is noticed that each time the leaf is rolled and fresh juice expressed, the rate of oxygen absorption increases temporarily.

The oxidization of the leaf juices is a surface action and on this account the reason for interspersing rolling with frequent periods of free oxidization, such as is possible during sifting, becomes apparent.

There are many systems of rolling, some of which are described elsewhere. The differences between systems occur in the speed with which the rollers revolve, the distribution of rolling and fermenting periods and the amount of sifting given to the leaf.

Generally speaking, the rolling system is governed by the air temperature, the condition of the leaf and the amount of machinery. In heavy cropping periods the number of rollers is often insufficient, and the ideal system has to be modified accordingly. In countries where air temperatures are low and a full wither can be obtained, the rolling is usually slow and thorough, with the rollers making about 45 r.p.m. and the roll lasting two to three hours. In countries where temperatures are high and a light wither practised, rolling is rapid, 70 r.p.m., and of short duration, lasting only one hour or 1½ hours.

The most suitable system of rolling is determined empirically and is based on the reports of tasters on the teas produced. The object of a rolling system is to bring

about oxidization in such a way that the best possible use of the tannin in the leaf is made, giving a nice balance of pungency or briskness, strength and body.

How to roll in order to develop quality, flavour and aroma is not clear, but it appears that treatment which brings about very full oxidization of the tannin masks or loses these properties.

After rolling the leaf is taken to the fermenting room where it is spread in a thin, even layer.

Fermentation

When tea leaf, either fresh or withered, is crushed or damaged in air it begins to turn red immediately, oxygen is absorbed, the water-soluble tannin content of the leaf decreases and heat is developed. Leaf which has been heated above 160° F. does not exhibit any of these changes.

The essential oil of tea, some chemical account of which has already been given, is formed during fermentation. This oil does not occur in fresh or withered leaf and results from the action of leaf enzymes on the leaf juices.

The substances responsible for the flavour and aroma peculiar to the teas of certain districts and at certain seasons are developed to some extent in fermentation, but they also appear to be present in some form in fresh and withered leaf. Green teas have flavour, and since these are unfermented the flavour does not result from enzyme action, but is either present in fresh leaf or is developed without the aid of enzymes during rolling.

The whole question of what may be termed natural aroma, as opposed to aroma formed in the fermentation of all tea leaf, is one on which little definite information is available. It is considered in some quarters that the natural aroma or 'spirit' of tea, to distinguish this

quality from that attributed to the essential oil, is present in fresh leaf. It is further considered that the 'spirit' is highly volatile especially at high temperatures and whilst the leaf is still turgid. In order to conserve the flavour of the leaf it is suggested that the wither should be a full, rapid one, carried out at low temperatures. This should be followed by a short fermentation, after which the leaf should be fired at a low temperature. When the leaf is almost dry it is considered that the 'spirit' is fixed and that the final drying may be at ordinary temperatures.

It is thought that the natural aroma is present in the leaf at all times of the year, but it is doubtful whether, if this is so, it is present in sufficient quantity to make it economically sound to work for its development at the expense of liquoring qualities. It will be noticed that the scheme of manufacture advocated to conserve the natural aroma is one that makes for thin liquors.

This question is one calling for further study.[48]

The water-soluble gummy matter in the leaf increases slightly during fermentation. If the leaf is allowed to ferment for a very long period, e.g. 24 hours, these substances may increase from about 3 per cent to 10 per cent of the matter in the leaf. The water-soluble solids decrease and the sugars increase during fermentation.

The acidity of the leaf juice increases after it has been expressed. The pH value has been observed to drop from about 5 at the beginning of rolling to 4·2 at the end of fermentation, under normal conditions in Assam.

It is considered that the set of reactions constituting fermentation is due to enzyme action. Tea leaf sterilized superficially with a solution of mercuric chloride ferments equally well as ordinary leaf, with similar oxygen

[48] Mr. G. S. Napier-Ford, of Messrs. Sanderson & Co., 23 Rood Lane, E.C., has given this aspect of tea manufacture considerable study, and has published confidential reports on the matter which are of great interest.

absorption and development of tea aroma, suggesting that micro-organisms take no part in these changes.

When tea leaf is rolled the rate of decrease in the soluble tannin is rapid at first, but falls off after about 3 hours. The table below shows the type of change which may be expected during the first 6 hours after rolling.

	Water-soluble tannin	Water-soluble tannin loss
	%	%
Withered leaf	19·25	—
Rolled 1 hour	15·38	3·87
Fermented 1 hour	14·33	1·05
,, 2 hours	13·42	0·85
,, 3 ,,	12·82	0·60
,, 4 ,,	12·39	0·43
,, 5 ,,	12·08	0·31
,, 6 ,,	11·90	0·18

The loss goes on at a diminishing rate for about 24 hours, usually after which the results of bacterial and other infection are apparent if fermentation is carried on in free air. Many of the micro-organisms which appear on the leaf thus exposed attack tea tannin and rob it of its tanning powers.

The amount of oxygen absorbed during fermentation follows roughly the change in water-soluble tannin.

The amount of water-soluble tannin which can be lost during fermentation is limited, and after a certain time no further appreciable loss takes place. Experiment in Assam has shown that even when leaf is ground up in a mortar till a paste is formed, the tannin does not fall below about 10 per cent, although grinding is continued at intervals for 24 hours. This phenomenon may be explained by supposing that the enzyme ceases to act after a certain time, perhaps because of the presence

of the tannin products which it has helped to form. It is also possible that the enzyme has oxidized all the tannin exposed to its action and to the air, and that this has then been precipitated by the leaf proteins as far as possible, there being insufficient proteins to precipitate all the tannin oxidized. In this case, the unprecipitated tannin would remain soluble, of course.

It is usual to ferment the leaf for a period of three to four hours, including the time spent in rolling. In such a time the optimum degree of tannin oxidization takes place and the aroma is developed to a maximum. A shorter period of fermentation gives a thin tea with a bitter taste, sign of under-oxidization, whilst a longer fermentation gives teas with soft, dull liquors, denoting over-oxidization of the tannin. The periods of time mentioned are approximate and departures from the limits given are frequently necessary.

The optimum time of fermentation depends partly on the air supply to the leaf and on the temperature. A period of 3 to 4 hours assumes a room temperature of about 80° F. and the leaf spread at a depth of 1½ to 2½ inches, which thickness ensures ample aeration.

Leaf heats up in the fermenting bed, and with a room temperature of 80° F. the temperature in the bulk of the leaf may rise to about 84° F. even with a spread as thin as 2 inches. Towards the end of the fermenting period the temperature in the leaf falls again to that of the room. With thick spreading, 4 to 5 inches, the thermometer may rise to 90° F. or so, and on this account the oxidization is hastened. On the other hand, when the leaf is spread so thickly the air supply is diminished, a circumstance which retards the rate of oxidization. On the balance it is generally seen that thick spreading retards the rate of oxidization and necessitates a longer period of fermentation than with thin spreading.

FIRING OR DRYING

During firing or drying, fermentation ceases and the leaf enzymes are inactivated. Some tea aroma is lost in firing. The smell of freshly fired tea suggests that some caramellization has taken place. The water-soluble tannin in the leaf shows only a slight decrease during firing. There is no important change in the other constituents of the leaf.

Bacteria, yeasts and other micro-organisms on the leaf, which have all been increasing in number during manufacture, are killed during firing, and finished tea, even after considerable handling, does not carry any considerable number of these organisms. Such that are present are of no practical importance provided the tea is dry. If tea is damp, moulds already present may develop and produce a mouldy smell and taste.

Some slight change takes place after tea is fired, and small quantities of carbonic acid gas are evolved. On keeping, tea is said to mellow, and the reactions which constitute mellowing are spoken of as post-fermentation. Since mellowing includes a loss of bitterness or rawness in the tea, the changes probably include the oxidization of tannin, which process will go on very slowly without the aid of the leaf enzyme.

During firing the moisture content of the leaf is reduced from about 65 per cent, more or less according to the degree of the wither, to about 2 per cent, which may increase automatically to about 10 per cent during sorting. The question of the optimum moisture content for packed tea is discussed elsewhere.

To fire tea successfully in the tea dryers used in India, Ceylon and Java, certain conditions must be observed. It is necessary to heat the leaf quickly to inactivate the enzymes, otherwise fermentation continues

in the dryer at an enhanced rate, producing soft, stewed teas. At the same time the leaf must not be submitted suddenly to a high temperature, otherwise it becomes case-hardened by the formation of a dry outer skin which imprisons moisture within the leaf.

To reduce both case-hardening and stewing to a minimum it has been found that the best temperature to which the leaf can be submitted on entering the dryer is about 140° F. This rapidly raises the temperature of the leaf to about 120° F. and fermentation is sufficiently arrested to avoid soft liquors.

In order to produce teas with keeping qualities the temperature of the leaf itself must be raised to about 170° F. On this account the initial temperature of the air as it enters the drying chamber and meets the dried tea about to be discharged should not be less than 170°. In practice the initial temperature is usually kept near 200° F.

Air temperatures much above 200° F. are liable to burn dry tea if the latter remains in such a medium for more than a few minutes, although moist leaf is not so affected.

A steamy atmosphere in the dryer is detrimental to quality in that an excessive amount of the essential oil in tea is thereby lost. Some loss of this and of the substances giving rise to flavour and aroma is unavoidable. An accumulation of steam in the drying chamber results from overloading with leaf and can be avoided by using a strong air blast.

China and India Teas

Some of the differences between India and China black teas will now be discussed. The former term is used to denote the type of tea made in India, Ceylon and Java. In these countries manufacture is carried out in the cool at temperatures not above 80° F. if possible.

Withering is a slow process lasting up to 24 hours, whilst rolling and fermentation are completed in about 3½ hours. Firing is carried out once and for all at the end of fermentation, and is completed in about 30 minutes.

In China the withering, fermentation and drying processes all proceed together, and after fermentation has been stopped by heat, rolling and drying are still continued alternately.

In making black tea in China, flavour is generally the chief consideration, whereas with the India type of black tea liquors are usually more important, except at certain seasons.

With the object of making thick, strong, pungent liquors, it is necessary to keep as much of the tannin and tannin products in the soluble state as possible, and the mode of manufacture in India is shaped to that end.

The method of preparation in China tends to lose soluble tannin. The leaf is withered in the sun till it begins to redden and it is sometimes warmed before it is rolled to make it supple. Both these processes make for what is known as 'red leaf' in India, and result in a loss of soluble tannin. The rolling in China is very thorough and the oxidized tannin formed in the process will be largely precipitated by leaf proteins.

After fermentation the leaf is killed in a hot pan and then further rolling takes place and no doubt further, albeit slight, loss in the tannin occurs. It is probable that oxidization rather than condensation now takes place, since the latter is not easily brought about in leaf devoid of active enzymes, although the oxidization of moist tannin when exposed to the warm air is comparatively rapid. The tannin products formed after fermentation are probably largely precipitated by leaf proteins.

Some of the finest black teas from China contain only about 4 per cent tannin, and the liquors are thin and soft.

Green Tea

The first process in green tea manufacture is the heating of the leaf to a sufficiently high temperature to inactivate the enzymes. After this, rolling and drying proceed alternately. Soluble tannin is lost in manufacture and since coloured tannin products do not enter an infusion of good green tea, the tannin products formed in rolling must either be insoluble or have been precipitated by leaf proteins.

As was pointed out in the case of China black tea, the condensation of the tannin in leaf which has been killed is hardly likely to take place, and the more likely change is oxidization, aided by heat, followed by precipitation with leaf proteins.

As will be described later, the manufacture of green tea in Japan includes four periods of rolling. The tannin change during manufacture is as follows.[45]

	Percentage
Fresh leaf contains	15·20 tannin
After steaming and rolling once	12·83 ,,
After third rolling	12·27 ,,
After fourth rolling	12·18 ,,

These changes may be compared with those observed during the manufacture of black tea in India and Ceylon.[49]

	India	Ceylon
	%	%
Fresh leaf	22·20	22·33 tannin
Withered leaf	22·18	22·13 ,,
Rolled leaf	18·23	20·75 ,,
Fermented leaf	12·88	13·24 ,,
Fired tea	11·99	12·92 ,,

49 C. R. Harler, 'Tea in Ceylon,' *Ind. Tea Assn. Quart. Jour.*, Calcutta (1924), pt. 4.

Chapter VIII

THE PHARMACOLOGY OF TEA

The food value of tea—Caffeine—Tea tannin and tannic acid—The influence of tea on digestion—The brewing of tea.

An infusion of dry tea leaf is used as a beverage on account of the stimulant, caffeine, it contains, although there is no apparent correlation between the market value of a tea and its caffeine content.

Black teas are valued highly on their flavour and aroma and the 'strength' of their liquors. This last quality depends on the oxidized tannin products in the infusion, substances for which tea drinkers acquire a taste.

Green teas contain as much and often more tannin than black teas, but it is practically all present in the unoxidized form. The stimulus given by green tea is, as with black tea, due to the caffeine it contains. It is said that green tea has an aphrodisiac effect, although it is difficult to see why this should be.

The immediate comforting effect which a cup of hot tea has on the system is due partly to the warmth it supplies, for the action of the caffeine is not apparent for some minutes.

The Food Value of Tea

Tea must be regarded wholly as a beverage, for its food value is negligible.

A tea infusion contains, in addition to caffeine and tannin, small quantities of protein bodies and carbohydrates. Neither are, however, present in sufficient quantity

to be of value in the normal diet of the average person. A cup of tea even when taken with milk only contains about 10 grains of proteins. This amount is insignificant when it is considered that the average man requires about 1,300 grains proteins each day, and usually consumes much more. The actual calorific value of a cup of tea has not been worked out with accuracy, but some cookery experts put it at 10. The average man requires from 2,500 to 3,000 calories a day. A half-pint cup of tea containing a tablespoonful of milk (10 calories) and one lump of sugar (25 calories) yields not more than a total of 45 calories.

It has been claimed that certain green teas are rich in vitamin C. A study of green tea infusions, however, has shown that the beverage does not contain a sufficient amount of vitamins to be of importance in the diet of the average person.[50]

It is considered that any vitamins in black tea as manufactured in India, Ceylon and Java would be destroyed during the firing process in which the leaf is subjected to a blast of hot air.

The ash of tea is strongly alkaline and contains about 50 per cent potash most of which enters the infusion. On this account some advertisers of tea claim that the beverage tends to alleviate acidosis in the human system and to reduce the tendency to gout. A discussion of this question would lead into the sphere of many controversial matters. The amount of potash, reckoned as oxide of potassium, in a cup of tea is somewhat less than half a grain.

Certain Asiatic people, notably the Shans, consume fresh tea leaf and in so doing follow a rational course since they benefit from the nutritive properties of the leaf. In Tibet a kind of soup is made of tea.

[50] U.S. Dept. of Agric., July 28th (1929), Bull. No. 578.

It is now proposed to consider in some detail the two most important constituents on a tea infusion, caffeine and tannin, from the point of view of pharmacology.

Caffeine

Caffeine is used as a drug and its action on the human system is stated in the *British Pharmaceutical Codex*, edition 1923, to be as follows.

> Caffeine exerts three important actions: (*a*) on the central nervous system, (*b*) on muscles, including cardiac, and (*c*) on the kidney.
>
> The action on the central nervous system is mainly on that of the brain, connected with physical functions. It produces a condition of wakefulness and increased mental activity. The interpretation of sensory impressions is more perfect and correct, and thought becomes clearer and quicker.
>
> With larger doses of caffeine the action extends from the physical areas to the motor area and to the cord, and the patient becomes first restless and noisy and, later, may show convulsive movements. Caffeine facilitates the performance of all kinds of physical work which can be obtained from a muscle. In the normal man, however, it is impossible to say how much the action of the muscle is central and how much peripheral. But, as fatigue shows itself first by an action on the centre, it is probable that the action of caffeine in diminishing fatigue, is mainly central. Caffeine accelerates the pulse and slightly raises the blood pressure. It has no action in any way resembling digitalis. By increasing the irritability of the cardiac muscle, its prolonged use rather tends to fatigue than to rest the heart.
>
> Caffeine and its allies form a very important group of diuretics. The urine is generally of a lower specific gravity than normal since it contains a lower proportion of salt and urea; but the total excretion of solids both as urea, uric acid and salts, is increased. Caffeine, by exciting the medulla, produces an initial vasco-constriction of the kidneys, which tends at first to retard the flow of the urine.
>
> The medical dose of caffeine is 1 to 5 grains (6 to 30 cg.).

This account represents considered British medical opinion and contains only such facts as thought sufficiently established for publication.

The caffeine content of tea varies from 2 per cent to about 4 per cent with an average of about 3½ per cent.

The annual tea consumption in Great Britain is about 9 lb. per head. This quantity of tea contains on the average about 2,205 grains of caffeine. Assuming about three-quarters of the caffeine is extracted when tea is brewed, the average annual consumption of caffeine would be about 1,654 grains (about $3\frac{3}{4}$ ounces). The average daily consumption in Great Britain is thus about $4\frac{1}{2}$ grains.

A pound of good tea makes about 200 cups of the beverage. Since this quantity of tea contains about 245 grains of caffeine, of which about 184 grains are extracted, each cup of tea made from freshly infused leaf contains about 0·9 grains of the stimulant. A second brew yields an infusion which only contains about 0·3 grains of caffeine per cup, and further brews are practically devoid of the stimulant.

Many experiments have been made on animals and human beings in the study of the effect of caffeine on heart action, blood pressure, muscular activity and so on. The most complete study of the subject was made by Hollingworth.[51] The experiments were carried out in an especially equipped laboratory and the subjects were treated with caffeine for a period of 40 days under controlled conditions. For details of the experimental technique reference should be made to a monograph in the *Archives of Psychology of the University of Columbia*, New York, entitled 'Columbia's Contribution to Philosophy and Psychology'.

The caffeine was given in capsules and in syrup, the dose ranging from 1 to 6 grains, above 4 grains being reckoned a large dose.

The general conclusions arrived at were that the effect of caffeine on motor processes is quickly realized and is

[51] H. L. Hollingworth, 'The Influence of Caffeine on Mental and Motor Efficiency,' *Ther. Gaz.* (1912), 28, No. 1, pt. 1.

transient, whilst that on mental processes comes more slowly but is more persistent. No secondary reaction was observed in any test, even with what was considered a big dose.

It was further observed that the two main factors which seemed to modify the influence of caffeine are body weight and the presence of food in the stomach. In practically all the tests, the influence of the caffeine varied inversely as the weight of the subject, and was most marked when taken on an empty stomach or without food substance. The effect of caffeine did not seem to be influenced by age, sex or previous caffeine habits.

The experiments just described were carried out with caffeine in the free state. No definite information regarding the state of caffeine in tea leaf or in dry tea can be given. It has been erroneously assumed in some cases that in a tea infusion the caffeine is combined in part with tea tannin, but evidence points to the fact that here the alkaloid is for all practical purposes free. This question has already been dealt with in Chapter V.

Although the caffeine in tea makes the beverage a stimulant, tea cannot be classed with stimulants which contain alcohol. To habitual tea drinkers it should be regarded as a cure for fatigue, much as food is a cure for hunger. It is not enough to satisfy the need, satisfaction must be renewed at intervals.

Tea Tannin and Tannic Acid

In discussing the action of tea tannin in the alimentary tract it is common for hostile critics of the beverage to refer to 'tannin' as though it were a single substance, instead of a generic term for a large group of widely different substances. It is usual, furthermore, for such critics to assume that tea tannin is the same in its action as the tannic acid commonly used in medicine. On this

account a few remarks about natural tannins in general and the tannins of pharmacopoeia will not be out of place.

Some years ago, before the study of the tannin group had advanced far, the term tannin was often employed to denote the tannin of oak galls. Nowadays the term tannic acid is used in pharmacopoeia to denote digallic acid. Present day chemists use the terms both tannin and tannic acid in the generic sense to denote a large body of substances which have certain properties in common.

Tannins are vegetable substances occurring in the higher plants. They are found in the bark of some plants, and in the wood, leaf or pods of others. The extraction of tannins for use in tanning hides is an important industry.

The chemical nature of tannins differ widely, according to their source. The extensive study of their reactions has furnished a basis for several schemes of classification. One well known scheme divides the natural tannins into two general classes which have been termed *pyrogallol* and *catechol,* from the fact that on dry distillation tannin materials give one or the other of these substances. The tannic acid of pharmacopoeia is a pyrogallol tannin, whilst tea tannin belongs to the catechol group.

In 1920, Freudenberg[20] offered a more distinctive classification of tannins based on structural differences in the molecule, made possible by the great advances in tannin research during recent years. Details of this classification are out of place here, but it is sufficient to say that the tannins are divided into two main classes, viz. hydrolysable and condensed tannins. The common tannin of pharmacy belongs to the former class and tea tannin to the latter.

The tannic acid or *acidum tannicum* commonly used in medicine is obtained by fermenting gallotannic acid, the tannin of oak galls. This natural tannin, penta-digalloyl-glucose, thus gives digallic acid, a simple

tannin whose constitution and properties are well known. The following extract from the *British Pharmaceutical Codex* is taken from the account given under the heading, ' Acidum Tannicum or Tannin ', and describes the action of digallic acid in the alimentary tract.

> The properties of tannin depend on its chemical interaction with protein or gelatine. . . . The free acid only is astringent and when it is neutralized by alkalies or albumin its astringent properties are lost.
>
> When taken by the mouth it gives the characteristic property of astringency, coagulates the protein material surrounding the epithelium and even penetrates some of the cells.
>
> In the stomach it combines with alkalies and albumin to form tannates. Albumin is digested like other coagulated proteins, the tannin being again liberated to recombine. The tendency in the intestine, by coagulating proteins and diminishing secretions, tends towards constipation. It is therefore used occasionally in diarrhoea.
>
> The proper dose is 5 to 10 grains (3 to 6 dg.).

Other tannins used in medicine are myrobolans, catechu and black catechu. Myrobolans is obtained from the immature fruits of the tree *Terminalia chebula* (Retz.). In small doses it acts as an astringent, reducing the secretion of the intestine and thus having a use in staying diarrhoea. In large doses, 30 to 60 grains, it activates the secretion of the liver and thus acts as a purgative.

Catechu is obtained from the tree *Uncaria gambia* (Roxb.), and black catechu from *Acacia catechu* (Willd.). Both are given in doses of 5 to 15 grains and act as astringents.

The chief properties of tannins have already been summarized in Chapter VI, and the fact that tea tannin is a pseudo-tannin pointed out. Digallic acid, the tannin of pharmacy, is a true tannin and as such precipitates proteins.

The digallic acid molecule has an entirely different structure from that of tea tannin. The tea tannin

molecule contains no carboxyl group and is a very weak acid. The pH value of both the pure tea tannin and the oxidized soluble products is 4·4, whilst that of digallic acid is 3·0. Thus the latter is about 25 times as strong an acid as tea tannin.

In two important respects, then, does tea tannin differ from digallic acid. First it is a much weaker tannin, and second it is a much weaker acid.

In the intestines where the medium is alkaline, tannins will only exert astringency and coagulate or precipitate proteins if the alkalinity is first neutralized or overcome. Although digallic acid can bring this about, it is such a weak acid that its action can only be local. This, in practice, is realized to be the case.[52] If digallic acid has such limited action, how much more feeble will be the action of an acid like tea tannin?

It is evident that to the average person tea is innocuous, but it is wrong to argue from the normal to the pathological case. No doubt the degree of alkalinity of the intestine varies with individuals as will also the amount of gastric juice secreted. The liability of the intestine to astringent action will also probably vary, and it is possible that in some cases conditions may be such that the action even of a weak tannin like tea tannin may be sufficient to impair digestion and to bring about constipation. In such cases tea should be taken weak.

The Influence of Tea on Digestion

Many years ago the effect of tea infusions on the action of the ferments of the mouth and the stomach were observed. Roberts[53] showed that a tea infusion, even as weak as 5 per cent, in the digestive mixture inhibits the action of ptyalin in saliva and stops the

[52] E. Whitta, *Elements of Pharmacy, Materia Medica and Therapeutica*, London (1915), 313.

[53] Roberts, *Digestion and Diet*, 120.

conversion of starches into sugar. This result is attributed to the tannin in the infusion.

Roberts further observed that tea infused for two minutes had just as powerful an effect as tea infused for half an hour. It was also noticed that a pinch of bicarbonate of soda added to a tea infusion completely suspends its inhibitory effect on the ptyalin. This action might be anticipated, and the addition of milk to tea will probably have an ultimately similar effect.

The observations of Roberts were confirmed by Robertson.[54]

Fraser[55] studied the action of tea on the digestion in the stomach and found that it retarded peptic action. A strong infusion has a more powerful influence than a weak one, and the addition of milk largely removes the retarding influence.

Roberts,[53] Ogata[56] and Schultz-Schultzenstein[57] have also recorded the same influence on peptic digestion. Here again the effect is considered to be due to the tannin in the tea.

The action of the volatile oil in tea has not been investigated to any extent and the tendency of recent observers is to minimize the importance of this substance as a factor in digestion.

Apart from the modifying influence of tea tannin on the chemical processes of digestion either by reason of its acidity or by its power to precipitate the ferments engaged in digestion, it is considered that tea tannin may act as an irritant to the mucous membrane of the stomach, especially if employed in strong solution. Furthermore, it is generally considered by doctors that tea should not be taken on an empty stomach, and not when the

54 W. G. A. Robertson, *Jour. Anat. Physiolog.* (1898), 32, 615.
55 Frazer, *Jour. Anat. Physiolog.* (1883), 18, 13.
56 Ogata, *Archief Hygiene* (1885), 3, 204.
57 Schultz-Schultzenstein, *Ziet. Physiolog. Chem.* (1894), 18, 131.

diet taken makes large demands on the peptic powers of the stomach, e.g. when meat is taken. These opinions are largely based on observations made with unmilked tea. The addition of milk by virtue of the protein it contains robs tea tannin both of its acidity and astringency.

In addition to the influences outlined above of tea on digestion, the beverage is often considered to lead to constipation. It is known that a total daily dose of 45 grains of the tannic acid of pharmacopoeia will completely constipate the average person in three days. In order to determine the effect of tea tannin in this respect, experiments have been carried out in Assam. Daily doses of 45 grains of tea tannin were administered for three consecutive days to several male adults, and in no case was constipation or indigestion registered.[58]

The tea tannin administered was extracted from fresh tea leaf in the pure form in some experiments, and as a mixture of pure and oxidized tannins from black tea in others. In some cases parallel experiments were made with digallic acid, and these always resulted in serious constipation. Although tea tannin never produced constipation, in two cases it brought about diarrhoea. It must be remembered, however, that 45 grains of tannin, the dose given, is equivalent to about 18 cups of strong tea. During the experiments under consideration, the subjects followed their normal habits and drank several cups of tea daily.

The probable action of the tannin in a tea infusion during its passage through the alimentary tract may now be considered.

When fresh milk is added to a normal black tea infusion no precipitation of caseinogen, the protein of milk, occurs. If milk is just 'on the turn', i.e. if it has

[58] P. H. Carpenter and C. R. Harler, 'The Chemistry and Pharmacology of a Cup of Tea,' *Ind. Tea Assn. Quart. Jour.*, Calcutta (1932), pt. 1.

developed sufficient acidity to bring the caseinogen to the point of coagulation and precipitation, oxidized tea tannin may complete the process. This accounts for the curdling of such milk when it is added to tea. The addition of milk to tea is, in effect, the addition of protein, and the result is that the astringent and acid properties of the tannin are allayed.

If tea is drunk without milk, then an astringency or contraction of the membrane is experienced in the gums.

When tea passes from the mouth through the gullet, the oxidized tannin therein is held by the caseinogen in the milk. When the tea reaches the stomach it enters a strong acid medium, with a pH of about 1·5, and even the unoxidized, pseudo-tannin is then fixed by proteins.

It is assumed in the *British Pharmaceutical Codex* that the protein complex attached to the tannin is decomposed by the stomach juices and the tannin liberated. If this is so, the freed tannin will then be largely precipitated if it is in the oxidized form, otherwise it will recombine with any food proteins or protein bodies it may find in the stomach. The fixation of some of the food protein is not a serious matter, since a cup of tea only contains a total of about 2½ grains of tannin. In the absence of sufficient proteins in the stomach to precipitate the tannin, the latter may exert its astringent action on the membrane of the stomach.

The popular idea of the stomach lining becoming tanned by tea so that it resembles leather is one to be mentioned only to be dismissed as foolish.

When the partially digested food in the stomach has reached a certain state it is sent into the small intestine, whence it in time passes to the large intestine and is eventually excreted. Throughout both intestines the normal reaction is alkaline. Any tannin bodies precipitated by the stomach acid will be redissolved in the

alkaline medium of the intestines, whilst any tannin-protein compound will be decomposed by the alkali, and the tannin again liberated.

The reaction of the tannin is now influenced by the alkalinity of the intestinal medium. If this is overcome, astringency will assert itself and combination with protein bodies again become possible. With such combination astringency is lost, so that any action in the intestine must be very local.

It is possible that tea tannin is rapidly oxidized to a phlobaphene in the intestine, which will end its activity as a tannin.

Considering the reactions of tea tannin and its products in the alimentary tract purely from the chemical point of view, it is difficult to see how they can exert any important degree either of astringency or acidity at any stage.

In Great Britain the average daily consumption of tea tannin due to tea drinking is about 13 grains. This figure is based on an annual consumption of 9 lb. a head, and it is assumed that on an average the tannin content of tea is 12 per cent of which 7 per cent, a little over a half, is extracted on infusion.

Assuming each pound of tea to give 200 cups, each cup of once infused leaf will contain about 2·5 grains tannin. The tea from a second brew will contain less tannin than the first.

Some mention of the probable effect on the digestion of the tannin in green tea must be made. Here the tannin is present almost wholly in the unoxidized form which, although a pseudo-tannin, has the same strength of acidity as the oxidized forms.

In the acid medium of the stomach the tannin in green tea will be precipitated by proteins, although when green tea is drunk it is not usual to supply the protein

in the form of milk. It is likely that tea tannin is oxidized in the intestine, in which case the action of the tannin in green tea would be expected from this stage onwards to be very similar to that in black tea.

The Brewing of Tea

Tea is best made with freshly drawn water which has just come to a vigorous boil. The prolonged boiling of water drives off all the dissolved air, and such water, until it is aerated again, has a characteristic which may be described as 'flat'. This property reappears in a tea infusion made with over-boiled water.

Tea should be infused for about 5 minutes, although the smaller grades like Fannings and Dusts yield strong liquors in a shorter time. During the period of infusion the hotter the water is kept the more solid matter is extracted from the leaf. The heat of the infusion may be conserved by placing a cosy over the teapot. Additional aids to this end are the use of an earthenware pot, and one which has been rinsed with hot water before putting in the dry tea.

In some countries it is customary to keep the infusion warm by means of a small lamp, as with the Russian samovar. The objection to the use of a lamp is that there is some chance that the tea may boil. In this case not only may undesirable tannin bodies be extracted from the leaf, but some of the essential oil, which is volatile in steam, may be lost. Another objection to placing a lamp under the teapot, or, in fact, to putting the teapot on a hot surface like a hob, is that the tea leaves lying at the bottom of the pot may become overheated and release undesirable products into the infusion. This objection does not arise unless large quantities of leaf are in the pot.

If undue heat is avoided the action of a samovar is the same as that of a teapot kept warm by a cosy provided,

of course, that the time of infusion is the same in both cases.

The amount of tea which should be used is governed largely by taste, but most tea drinkers have settled down to the empirical rule of adding one teaspoonful for each person and infusing for about five minutes. Custom usually demands that one extra spoonful be added 'for the pot'. Another useful measure is the addition of one level spoonful of tea for each breakfast cup made.

Actually about 3 gm. tea per 150 c.cm. water are employed. Thus with a quart teapot, holding 6 tea cups or 4 breakfast cups, about two-thirds of an ounce of tea are taken. At this rate the number of cups per pound of tea is 144. It is usual to serve hot water with tea which is added to the pot after some of the tea has been poured out. On this account the actual number of cups per pound is about 200. Unless tea is to be watered, much less than two-thirds of an ounce would be added to a quart teapot.

It is instructive to examine closely the matter extracted by a five-minute infusion of tea. With a fine broken grade of Assam tea, such an infusion extracts more than half the tannin, three-quarters of the caffeine and more than half the total soluble solids. Following is a table showing the total tannin, caffeine and soluble solids extracted by an hour's boiling compared with that

	Boiling 1 hour	Infusion 5 minutes	percentage of total extracted
	%	%	%
Tannin	12	7	58
Caffeine	4	3	75
Soluble solids	37·5	23	61
Tannin bodies	2	2	100

extracted in five minutes. The third column indicates the percentage of the total which is extracted in five minutes.

It will be noticed that the tannin bodies, substances which have practically no tanning power and which are precipitated as a large part of the ' cream ' when tea cools, are practically all extracted in a five-minute infusion. This accounts for the fact that a second infusion does not ' cream down '.

In Amsterdam, the Trade Museum, at the instigation of the Tea Growers Association of Netherlands India, carried out detailed experiments on tea brewing with Java teas. The results obtained were of the same order as those already detailed except that a smaller proportion of tannin was extracted in a five-minute infusion. This difference may have resulted from the use of leaf grades in the case of Java teas, which give up their tannin less readily than broken grades.

In the Amsterdam experiments tea was infused for five minutes, the infusion poured off and a second brew made and allowed to stand for 20 minutes. This second brew was then poured off and, like the first, analysed for caffeine, tannin and soluble solids. Another set of samples was infused for 33 minutes and the brew analysed. The results of these observations are shown in the next table as percentages of the total caffeine, tannin and soluble solids in the leaf.

Infusion	Caffeine	Tannin	Soluble solids
	%	%	%
1. Five minutes under cosy	80	40	60
Second brew twenty minutes under cosy	20	20	25
2. Thirty-three minutes under cosy	100	60	85

It will be seen that one brew of 33 minutes extracts about the same amount of matter as two brews, the first of 5 and the second of 20 minutes.

The second brew contains only a quarter of the caffeine in the first and is of less value as a stimulant to that extent. The second brew does not contain as much tannin as the first, although the tannin in the second case may have more marked tanning qualities than that extracted by a short infusion.

A second brew does not taste very pungent, probably on account of the dilution of the tannin, but the infusion given by a long single brew is often unpleasantly pungent. This indicates that the unpleasantness arises from the concentration rather than the nature of the tannin.

The action of milk on a tea infusion has already been discussed. The addition of sugar sweetens the infusion and lemon flavours it. So far as can be judged these substances have no other action on the infusion.

PART III

THE TEA COUNTRIES OF THE WORLD

Chapter IX

TEA IN CHINA

Historical and descriptive account of tea in China—The tea districts and markets of China—The preparation of black tea in China—Green tea—Oolong tea—Scented tea—Brick tea—The classification of China teas.

China, the classic tea country, gave both the word tea and the beverage to the world. Yet, in spite of the fact that the tea bush has been cultivated and the leaf prepared in China for many centuries, very little accurate information about methods in this country is available, and practically no scientific data.

The export trade in China tea was enormous in the latter part of the nineteenth century but, largely due to competition from India and Ceylon, it has now dwindled to a fraction of its former size. In the meantime, the methods of the tea farmer appear to have suffered little change and, in the years to come, the domination of the world tea market by the product of China may be looked upon as an incident in the long centuries of tea farming in this country.

On the other hand, China, possessing all the advantages that hereditary aptitude can bestow in the preparation of tea, may modernize and rationalize her industry and again become an important factor in the export tea trade.

Historical and Descriptive Account of Tea in China

The origin of tea and its preparation has its roots in mythology. The introduction of tea is sometimes attributed, out of courtesy, to the Emperor Shin Nong

who lived in the third millennium B.C. Another myth relates how Dharuma, a Buddhist monk who came to China in the fifth century A.D., was responsible for tea. This sage, during one of his prolonged periods of meditation, found that he was becoming drowsy. Seizing his offending eyelids he cut them off and cast them from him, and where they fell a plant grew, the tea plant, from whose leaves can be prepared a drink which drives away sleep.

The first authentic account of tea was written by Lo-yu who lived about A.D. 780. He describes the preparation of the leaf which, he says, must only be picked during certain moons, and not when it is raining or the sky cloudy. The leaf is manipulated in the hands and then dried and sealed. There are a thousand and ten thousand teas, adds Lo-yu.

Other early authors in describing the manipulation of the leaf speak of the use of steam. Steaming was carried out to extract the bitter water from the leaf, which was then rolled with the hands or in cloths, and dried sometimes in the sun or over a charcoal fire. Whether the earlier teas were powdered or pressed into cakes is not clear. In any case it is generally believed that the present method of preparation, in which each leaf is separate, was known at the time of Lo-yu.

At what period the two processes of *chao* and *poey*, roasting and drying, as at present employed, were introduced into tea preparation is not known. It is now generally considered that leaf which has been roasted (*chao*) in an iron pan (*kuo*) and finally dried over a charcoal fire (*poey*) is superior to leaf which is steamed and sun-dried. These processes will be referred to again later.

In early times tea was idealized and we have Chinese poets writing of the drink in the following strain. ‘The

first cup moistens my lips and throat, the second cup breaks my loneliness, the third cup searches my barren entrails but to find therein some five thousand volumes of odd ideographs. The fourth cup raises a slight perspiration, all the wrong of life passes away through my pores. At the fifth cup I am purified, the sixth cup calls me to the realms of the immortals. The seventh cup—ah, but I could take no more. I only feel the breath of cool wind that rises in my sleeves. Where is Horaisan? * Let me ride on this sweet breeze and waft away thither.'

The words *te*, *chia* and *cha* denote tea in various Chinese dialects, and in one or other of these forms has been transposed into most other languages.

Tea was known in Europe in the middle of the sixteenth century, and the Dutch began importing it early in the seventeenth century.

In Queen Anne's reign tea drinking in England became fashionable and rapidly spread. In 1703 the import into England was 100,000 lb. About a century later, in 1805, it was 7½ million lb. Tea was still then a 'China drink' and remained so for many years to come. China has exported more than 300 million lb. of tea in one year, and at one time tea ranked first in China's exports.

The growing importance of the tea trade in the eighteenth century was the origin both of the American bid for supremacy in the carrying trade and the successful reply of the British sailing ship designers with that series of famous tea clippers from the *Challenger* to the *Thermopylae* and the *Cutty Sark* which, with the wool clippers, made the British merchant sailing vessel the finest and fastest in the world. These clippers carried the early teas to London and the story of the race between the

* The Chinese Elysium.

Taipeng and the *Ariel* from Foochow to London in 1866 with first crop teas has now become history.

In the 'eighties China still supplied the bulk of the tea consumed by the world, but by this time the industry in India was getting into its stride, Ceylon was putting out tea and the commercial possibilities of tea in Java were realized. With a change in the style of manufacture in the tea countries controlled by Europeans, a product different from China tea was put on the market. The general public gradually showed its approval of the new commodity, with the result that China tea was ousted and to-day is no longer a serious rival to India, Ceylon and Java tea. The decline of the China tea export trade is striking, even in the present century.

Export of Tea from China in million lb.

	Black and Green	Brick and Tablet
1899	153·6	71·2
1913	109·2	82·2
1923	98·2	8·8
1927	77·6	38·6
1928	76·8	46·6

The loss of the export trade was not only due to external factors. Backward methods of cultivation, scattered holdings, lack of systematic planting, absence of capital in the hands of the farmers, complete lack of knowledge as to how to maintain the quality of teas in less favoured years, unwillingness to improve quality—all this has contributed to the rapid disintegration of the tea trade in China, making it give way before the competition of other markets.[59]

[59] Boris P. Torgasheff, *China as a Tea Producer*, Shanghai (1926), 81.

Russia remained in the China tea market longer than other countries partly because of large sums of money invested there, but even in the decade before the War Russia began taking large quantities of other tea, and in the last pre-War years about half the Russian consignment was from Ceylon.

The Chinese saw their market disappearing with natural concern, and sent a special commission to India and Ceylon in 1905 to observe methods. As a result, a special school was opened at Nanking for the study of modern methods of tea culture. In 1915 the Government organized a modern plantation in the Kimun area, and established control committees to organize the development of the industry. Among private attempts to improve matters may be mentioned the modern tea plantation at Ningchow.

Lack of organization of the export trade has also been open to criticism. Before the tea reaches the exporting firm it passes through numerous middlemen and pays many illegal taxes, with the result that the producer receives a very low price even for the finest tea, a fact which robs him of the incentive to produce the best.

The Tea Districts and Markets of China

Regarding the early geographical distribution of tea in China, Chinese authors state that it was first discovered in the Vu-ye or Bohea mountains in the Fu-kien province. It has also been reported by early writers to have been found in Sze-chuan, in the Singlo Hill or green tea district of Kiang-nan, and in various other provinces. In comparatively recent years it has been reported growing as far north as Manchuria.

In the early days of the tea trade with Europe, the Kwang-tung province, exporting from Canton, was the

centre of the business. Later this province was practically ousted from the market and the trade moved to the Fu-kien province, with Foochow as the business centre. To-day Canton exports mainly Congous and Orange Pekoes, with smaller quantities of Souchongs and Oolongs, but the trade is very small.

Foochow touched its peak in the tea trade soon after 1880. After this the China tea trade began to centre on Hankow, and later the development of the trade in India and Ceylon robbed Foochow of further business. Foochow and the nearby port of Santuao deal mainly in Congous and Oolongs.

Amoy, also in the Fu-kien province, was at one time a tea port and dealt with much of the Formosa trade. Since that island became part of the Japanese Empire in 1894 the ports of Formosa have been developed and Amoy has suffered accordingly.

Nowadays the cultivation of tea for export is concentrated in the five provinces of the Yang-tsi basin, Hu-peh, Hu-nan, Kiang-si, Anh-wei and Che-kiang, and in the Fu-kien province.

Hu-peh is the most important province producing black tea for export, and the greatest tea mart in China is Hankow which deals with about four-fifths of the export black tea trade. This city, situated about 600 miles up the Yang-tsi from Shanghai, was opened to foreign trade in 1861 and is served by large ocean-going steamers. The tea market opens about mid-May and lasts till the end of October, but the most active period is from the end of May to the beginning of July. Up to 1890 the British had full control over the Hankow market but then interest began to centre on India and Ceylon, and the control passed to Russian hands. By 1915 the export of brick tea alone from Hankow was reckoned at 80 million lb.

With the collapse of the Russian market in 1918 the tea trade of Hankow was paralysed, and since the crisis the export of black teas from Hu-peh has been largely carried on by trans-shipment from Shanghai.

Hu-nan exports black teas which are dealt with in the Hankow market. Teas from the Kiang-si province are marketed largely at Kuikiang which as a mart comes second to Hankow. Most of the Kiang-si black teas are sent to Hankow for trans-shipment, whilst the green teas are sent to Shanghai. Like Hankow, Kuikiang was badly hit by the failure of Russia in 1918, and both places await the Russian trade revival.

Tea production in the Che-kiang province is, as far as export is concerned, limited to green tea. Hangchow, Ningpo and Wenchow deal with the export, although much is sent to Shanghai for trans-shipment. Some of the teas from the Anh-wei province are also exported from Hangchow, although a fair amount is now dealt with at the Yang-tsi port of Wuhu.

Yun-nan and Sze-chuan deal mainly with poor grade compressed tea which is sent to Tibet. The leaf is softened by steaming, mixed with rice water and moulded into balls by hand. The rice water supplies a stickiness to the ball and helps it to keep its form. Sze-chuan black teas are sent to Ichang, whence they go to the Hankow market.

Tea is also produced in the northern provinces of Shan-si, Shan-tung, Kiang-su and Ho-nan, and in the southern provinces of Kwei-chow and Kwang-si. Most of this tea is used for local consumption and is not marketed at all.

During the past few critical years in the China tea trade, since the eclipse of Hankow, business has migrated to Shanghai, and it is now usual to tranship most of the up-country teas marketed at the Yang-tsi ports at

Shanghai. At the same time there is an increasing tendency for tea firms to do their business and buying at Shanghai.

Tientsin and Kalgan were at one time important transit markets for teas going to Russia. The usual route then was Hankow, Tientsin, Kalgan and across the Mongolian desert to Kiakhta on the Siberian frontier. The organization and maintenance of the caravans brought prosperity to the population along the route. The year 1899 saw the peak of the overland trade, but the Boxer Rebellion in the next year seriously hampered this type of transport and the railway route was favoured. With the return of normal conditions the overland route was not reopened to any great extent and, except for a short period of revival during the Russo-Japanese War in 1904-5 when the Trans-Siberian Railway was closed to private traffic, the caravan route has fallen steadily into disuse. Now Kalgan only serves as a centre for teas going to Mongolia.

No reliable figures for the acreage under tea in China nor of the annual production are available. Tea growing is a village industry and families produce for their own use. Thus any estimate nearer than a guess is out of the question.

Judging by the population of China, estimated variously between 300 and 400 millions, and considering the widespread and frequent use of tea, an estimate putting the annual production between 600 and 800 million lb. may be taken as a first approximation. In the prosperous period of the export trade the production will have been much higher.

The Preparation of Black Tea in China

The preparation of black tea in China is a process open to an endless number of variations and modifications. The literature on the subject is by no means

plentiful, and many of the more recent accounts are based largely on observations made by Fortune, Ball and Jacobson during the first half of the nineteenth century.[60]

Very broadly speaking, the preparation of black tea outlined in Chapter VI covers most of the possibilities included in reliable accounts of the procedure.

Samuel Ball, in his account of the culture and manufacture of tea in China, published in London in 1848, summarizes the method of black tea manufacture as follows.

> Place the leaves in a sieve,
> Expose them to sun and air,
> Toss them and turn them as hay,
> Then place them in the shade till they give out fragrance,
> Roast them in an iron vessel,
> Roll with the hands or feet,
> Finally dry over a charcoal fire,
> And you have a fair Congou tea.

Congou is a general term for certain China black teas, and is a word derived from the Chinese *koong-foo,* meaning the laborious or assiduous sort, more time and labour being expended on this than on other varieties.

The exposure to the sun and air is carried on till the shoot is so withered that the stalks can be bent without cracking. This period of exposure should only last for an hour or two and is not easily carried out in dull or rainy weather. The leaves are next lightly turned and manipulated till they turn red at the edges and develop red spots. The bruised leaves are now put in a cool place to ferment, a process which may last up to six hours, according to some writers, but one which is governed by the development of the aroma.

[60] R. Fortune, *A Journey to the Tea Countries of China,* London (1852). *Two Visits to the Tea Countries of China,* London (1853). S. Ball, *Cultivation and Manufacture of Tea,* London (1848). J. J. L. L. Jacobson, *Handboek voor de kultuur en fabrikatie van thee,* Batavia (1843).

When fermentation has proceeded far enough it is stopped by throwing the leaves into a shallow iron pan or *kuo* which is made very hot, almost to dull redness, by a wood fire. The temperature of the pan may or may not have an important bearing on the type of tea made. It is stated in some literature that in making the finest Souchongs the Chinese use red heat in the *kuo*.

The leaves, which crackle when thrown into the pan, are rapidly manipulated. The fragrance gives way to a vegetable smell, which later disappears and the fragrance returns. The leaves, now supple, are rolled on flat trays.

The roasting process kills the leaf, and the subsequent chemical changes which take place resemble those in green tea manufacture.

After some rolling the leaf may be replaced in the *kuo*, now cooler than before, and given further heating. Alternate rolling and heating may take place several times.

The final drying of tea is done with great care. The process is called *poey* and is carried out on trays placed in tubular, waisted, open-ended baskets called *poey-long*. These baskets are about 2½ feet high and are placed over a charcoal fire. The bamboo tray carrying the tea is placed in the waist of the basket and great care is needed in firing, for if leaf falls through the tray into the fire the smoke arising may taint the tea.

After half an hour or so the tray is removed from the basket, the leaf turned and manipulated, and then the tray is replaced. This kind of drying and manipulation continues till the leaf is too crisp for further rolling. As drying proceeds the fire is damped down with rice husk or ash. The process is a very slow one and may last several hours, the final stages being executed over a small fire with the top of the *poey-long* covered with a tray.

The teas are sent to central factories or *hongs* for final packing, where they are selected and made up into suitable parcels, *chops* or breaks of convenient size for selling to tea exporters.

The above account, which is gathered from Samuel Ball's work, probably represents in many ways the ideal, and may be contrasted with a very vivid recent account of the preparation of black tea in the Keemun district.[61]

Keemun teas are produced in the country round Kimun City in the Kiang-si province. As teas they draw a thick, sappy liquor and are distinguished by a rich aroma and flavour found in no other kind but the true Keemun.

The account states that the tea in the Keemun district grows with little attention in the way of cultivation. Pruning and fertilizing are unknown and many of the bushes are choked with weeds. When the spring flush appears, the owner of the bushes and his family strip them of all their green leaf, for there is no premium on careful plucking since all the leaf is mixed up in the central factory, where twigs and rubbish are picked out by hand by children.

During the autumn, winter and early spring the tea factories are deserted, and the question of labour at first seems a problem. A few days before plucking, however, the paths over the hills are alive with an endless procession of people who seek work in the villages, on the hillsides and in the factories.

As soon as the sun is up and the dew off the leaf, plucking begins. When sufficient leaf has been gathered it is spread thinly on matting in the sun to wither. When sufficiently pliant it is placed on the rolling table, where

[61] S. W. Harris, *A Trip to the Keemun District,* published by Messrs. Harrisons, King & Irwin, Ltd., Shanghai.

it is manipulated and bruised. When fermentation has started the leaf is put in large baskets covered with cloth and placed in the sun. Here it may be left for an hour or two hours according to the temperature of the day, and the leaf is stirred at intervals. When it is bright copper coloured it is spread in the sun and the colour turns black.

When properly sun-dried the leaf loses 50 per cent or more of its original weight. Assuming the fresh leaf to contain about 70 per cent moisture, the sun-dried leaf would then contain 40 per cent or less moisture.

The villager now puts the leaf into a bag and takes it to the nearest village where it is sold to the depot paying the highest price. The depot sends the leaf to the factory where it receives a preliminary fire to give it keeping qualities.

When sufficient leaf has been collected in the factory it is sorted mechanically or by hand sieves, and then finally fired in baskets in the manner previously described. Although slow and laborious, basket firing is considered preferable to machine firing, for it gives teas with superior keeping qualities, better flavour and liquors.

The leaf is then bulked, again lightly fired and packed warm in lead-lined half-chests ready for transporting to the market at Hankow.

The writer of the account of tea preparation in the Keemun district draws attention to the fact that weather conditions greatly influence manufacture, and that since the finest Keemuns are all made in a fortnight the variation in quality from year to year is understandable.

It will be noticed that the foregoing account differs in several respects from that given by Ball, and that no reference to roasting (*chao*) as a means of stopping fermentation is made.

Green Tea

In making green tea the sooner the leaf is roasted or steamed after plucking the better. As there must often be a lapse of time between the bringing in of the leaf and the heating process, it is necessary during this delay to keep the leaf cool. Exposure to the air before roasting is unnecessary, and to the sun, injurious. The *kuo* or iron pan used for roasting green tea is deeper than that used in black tea preparation, and more leaf is added at a time. In roasting, the leaf becomes a light yellowish-green in colour and there is a development of steam.

After roasting, the leaf is rolled in the same manner as in black tea preparation. First the leaves are placed on a flat tray and rolled into a ball. The ball is then shaken to pieces, and the leaves twisted between the palms of the hand. They are then spread out and allowed to stand in a cool room. Another roasting follows, this time in a cooler pan and accompanied by much manipulation. When the leaves have become fairly dry and turned a dark olive green, almost black in colour they are removed and cooled again. For the third time the leaf is roasted, this time in a still cooler pan and during this period they take on a bluish tint or bloom.

The bloom on the leaf is mark of quality, and at one time it was customary to add artificial colouring to the pan to give spurious quality to inferior tea.

An account of the preparation of green tea in Japan which follows in the next chapter describes the steaming process which is there used in place of roasting.

Oolong Teas

Oolong teas derive their name from the Chinese word *ou-long*, signifying black dragon, which is applied to

a variety of tea prepared in a certain manner, and having a small, greenish-yellow leaf scattered through it. There are several kinds of Oolongs, e.g. Amoys, Foochows, Formosas, Ankis and Padre.

Oolong teas are semi-fermented. Their preparation resembles that of black tea, but the fermentation is carried less far. In the character of their liquors, Oolongs are intermediate between green and black teas. Some details of the preparation of Oolongs is given in the next chapter in the section dealing with Formosa teas.

Scented Teas

The scenting of teas in China is described in some detail by Ball. Various flowers, preferably full blown, separated from their stalks, are used for the purpose. The *Chloranthus inconspicuus, Jasminum sambac, Olea fragrans* and *Gardenia florida* are commonly employed, but many others are said to be eligible for the purpose.

Green tea is scented as follows. The tea is taken from the basket (*poey*) when fully fired, and whilst still warm poured into a chest to form a layer about 2 inches thick. A handful of flowers is strewn over the tea, then another layer of tea is added, followed by more flowers and so on. A proportion of about 3 parts by weight of flowers to 100 parts of tea is usual. The chest is kept for a day, when the mixture is put through the process of *poey* with the basket completely closed at the top. The heating lasts about two hours by which time the flowers are quite crisp. The flowers are then sifted out and the tea packed.

The tea thus prepared may be mixed with unscented tea in the proportion of 1 of scented to 20 of unscented. The whole is then slightly heated in an iron pan as in the *chao* process, and when packed forms what was known in England in earlier days as Cowslip Hyson.

In scenting black tea a different method is used. The flowers are slowly dried in a basket (*poey-long*) and then powdered. The powder is mixed with the leaf during the last two dryings and rollings of the *poey* process or, more economic and usual, the powder is sprinkled over the leaf during the final process of *poey*.

Brick Tea

The manufacture of brick tea was known in the Sung dynasty (A.D. 966-1276) and brick tea was sent to the Emperor in golden boxes as tribute. Brick tea began to appear in Siberia in the seventeenth century.

When Foochow was opened to foreign trade, the Russians started to manufacture brick tea there by machinery. In 1882 the transference of the business to Hankow began, and in the last years of normal conditions no less than 90 per cent of the brick tea exported was made here.

The main business of manufacture and export is in the hands of Russian firms, although there are Chinese factories. British capital has been interested in this considerable undertaking.

The equipment of the Russian factories contains all modern devices and machinery. An outline of the process has already been given. For making black brick tea, leaf and dust are used, and much of the latter is imported from Ceylon and India. Before the War as much as 30 million lb. were imported in one year.

For green tea bricks only leaf is used without any admixture of dust or stalk.

In the preparation of brick tea, adulteration is possible and common. Twigs, both of tea and other plants, wood, pine bark, foreign leaves, sawdust and even soot are sometimes incorporated with tea leaf. Much poor, coarse leaf is used in brick tea, and it is

considered that brick generally represents about one-sixth the strength of an equal weight of good leaf tea.

The usual dimensions of a black brick are 8 by 12 inches and an inch thick. Green tea bricks are 7 by 12 inches or 8 by 5·2 inches. A brick weighs about 2¼lb. Bricks are packed in baskets which take from 36 to 144 bricks, although it is common to include about 80 bricks in one packet.

Although Russian brick teas have up to twenty grades the difference is so small that for practical purposes they may be divided into three grades.

Tablet teas are made in the same manner as brick teas, but only the finest dusts are used. Brick and tablet teas pay less duty in Russia than leaf teas or dust, a fact which encourages the manufacture of compressed teas.

The Classification of China Teas

There is no standard classification of China teas. In the broadest sense teas may be divided into two groups, leaf and compressed. Compressed tea may be in brick, tablet or ball form. Both leaf and compressed tea may be black or green.

The most complicated and varied method of classification is according to place of origin. This place may not necessarily be where the tea is grown, but may be where it is manufactured and graded. In some cases teas are named after other, quite different, districts because they resemble the teas of that district in quality.

Teas may also be classified according to the method of preparation, to the time the leaf was picked, and the age of the bush from which it was picked. Each kind of tea also has a number of grades.

In order to avoid the complications arising from the above systems, exporters of China tea have established

a method of classification of their own to answer the practical needs of the trade, based partly on the source of the tea and partly on the method of preparation.

The first attempt to classify China teas for export was made by J. H. Wade, a noted British authority on tea, who distinguished 22 classes of black and 6 of green teas. Boris P. Torgasheff, in a recent classification which is more discerning, distinguishes 64 classes of black and 48 of green teas. These names are only of interest or use to wholesale buyers of China tea.[62]

Teas exported do not always keep their original Chinese names and are often known by quite different appellations. The following are some of the well-known marks of both black and green China teas. From Anh-wei province: Keemuns. From the Kiang-si province: Ningchows, Kut Oans and Kien Tucks. From the Hu-nan province: Onfars and Shan Tams. From the Hu-peh province: Ichangs. From the Fu-kien province: Pan Yongs, Paklums, Chingwos, Paklings, Saryunes, Souchongs and Lapsangs. These are all black teas. Well known green teas are Moyunes and Tien-kais from the Anh-wei province, and Hoochows and Pingsueys from the Che-kiang province.[63]

A classification of China black teas based partly on the method of curing or preparing the leaf and partly on the fineness of the leaf contains about a dozen groups. The method of preparation varies from the complicated process involved in making Congou to the simple one of preparing Flowery Pekoe, which consists of little more than very careful drying. The fineness of the leaf varies from the youngest and most tender buds which constitute Flowery Pekoe to the coarse leaf employed in

[62] The classification of China teas is dealt with fully by Torgasheff in *China as a Tea Producer*.

[63] *Tea Talks*, No. 7, published by J. C. Whitney & Co., Shanghai.

making Bohea. Teas in this classification include the following groups.

Most of the black teas exported from China are known as Congous, teas which are prepared with a great expenditure of time and trouble in the manner described earlier in this chapter. They give strong, dark infusions compared with other China teas. These teas are subdivided into North China Congous or Monings (black leaf) from Hankow and South China Congous (red leaf) from Foochow. A notable red Congou is the Honeysuckle Congou coming from Canton.

Caper tea is a black tea twisted into small balls.

Souchong teas are made in the Congou manner but from coarser leaf. The term is derived from the Chinese *siao-chung,* meaning small sort. Souchongs often excel in cup quality but are not stylish in appearance. A kind of tea known as Padre Souchong is made by the Buddhist monks in the Vu-ye Shan (Wu-I-Shan) or Bohea mountains.

The term Bohea is applied to some teas, and was the name first given to the finest black teas but is now used to designate the lowest type, made from the last pluckings of the season.

Pekoe, Orange Pekoe and Flowery Pekoe are three classes of tea whose names partly indicate the fineness of leaf constituting the class. The term Pekoe is derived from the Chinese *pek-ho,* denoting white hair or down, and refers to the fine hair seen on the buds and younger leaves. When fermented tea juice is smeared on these hairs they appear yellow, orange or golden in colour. Flowery Pekoe is made from the tenderest buds which appear in the spring and is unfermented. This class of tea consists mainly of silvery flower or 'tip'.

Paklums are prettily made teas resembling Flowery Pekoe, although the leaf is black with some 'tip'.

Panyongs, Soomoos and Suey Kuts are specially prepared teas which, like the Paklums, come from the Fu-kien province.

Some of the special teas are scented. Foochow Scented Orange Pekoe is one of the most desirable, and the finer grades of this tea are a beautiful yellow or olive green in colour and consist of closely rolled leaf with some flower.

Mention has already been made of Oolong teas which constitute a separate group. They are further classified according to the district in which they are made.

Green teas are classified according to the way the leaf is rolled and according to its size, and further by the place of origin. The chief grades of green tea are Gunpowder, Young Hyson, Hyson and Imperial. Other grades are Waisan, Sowmee and Hyson Skin. The Chinese name for Gunpowder is *Choo-cha* or Pearl tea, a name which indicates its small round form. The true Imperial, known in China as Flower tea, is not exported. The term Young Hyson is derived from the Chinese *wu-he-tsien,* meaning early spring, and is applied to this tea because the leaf is plucked at this time.

The term Twankay is sometimes used to denote a grade of green tea. This term is derived from the Chinese *Taung* and *Kei,* the names of two rivers in the Anh-wei and Che-kiang provinces, and was originally used to designate the teas from this district.

Gunpowder, exported in three grades, first, second and third, occupies first place amongst exported green teas. It is made from the most tender buds rolled into little balls, ranging from Pinhead to Pea Leaf, the smaller the ball the more expensive the tea. Gunpowder gives a straw-coloured liquor.

Young Hyson is exported in five grades. It is prepared from young leaves, well rolled and twisted, and

ranks next in quality to Gunpowder. Hyson is made from larger, more mature leaves and is exported in three grades. Its infusion is bitter and astringent. The Imperial grade made for export consists of the older leaves made in the Gunpowder style but more loosely rolled.

In the tea trade, these names are only used to describe the style and make of the leaf after it has been prepared, and are qualified by the name of the district in which the leaf is grown. Some such, already mentioned above, are Moyune, Tienkai, Hoochow and Pingsuey.

The Chinese themselves place teas into five groups, red, green, yellow, red brick and green brick. Each group is sub-divided into four grades, rough, tender, old and new. Thus there are twenty kinds which are again divided into well-made and ill-made teas. To this classification is added the name of the province and the district of origin, with the result that the complete classification consists of several thousand grades.

Yellow tea is not exported. It is known as Mandarin tea and before the days of the Republic was prepared in certain places for persons of rank at the Imperial court. This is a very fine tea made from the youngest buds.

CHAPTER X

TEA IN JAPAN AND FORMOSA

The tea industry in Japan—Organization of the tea industry—The tea crop in Japan—Pests and blights—Preparation of Japan green tea—Uji tea—Powdered and patent teas—Re-firing tea for export—The quality of Japan tea—The grading of Japan teas—Tea ceremony in Japan—Tea in Formosa.

JAPAN proper consists of four large islands—Hakkaido, Honshu, Shikoko and Kiushiu—and numberless small ones. The country is for the most part mountainous, the only considerable plain being that about Tokio. There are slight earthquake tremors daily, perceptible by delicate instruments, several severe shocks yearly and at intervals a terrible catastrophe, causing widespread destruction. Devastating tidal waves produced by submarine earthquakes are frequent. All these seismic movements are largely traced to the fact that the shores on the Pacific side are slowly rising and those bordering on the Sea of Japan are sinking. A geological fault is supposed to run along the west of the country.

According to legend, now firmly established, Lake Biwa, near Uji, owes its existence to a great earthquake in the year 286 B.C., whilst Fujiyama, the sacred mountain of Japan, rose out of the plain of Suruga at the same moment.[64]

THE TEA INDUSTRY IN JAPAN

Although Japan is the first industrial nation in the east, her population is still essentially an agricultural one. Tea farming is a subsidiary industry, for the cultivator

[64] Most of the information in this chapter is taken from an article, 'Tea in Japan,' by C. R. Harler, *Ind. Tea Assn. Quart. Jour.*, Calcutta (1924), pt. 1.

prefers to plant his flat land and best areas with other crops. The result is that tea is relegated to hillsides and to areas often remote from the railway and deficient in means of transport.

Tea and mulberry cultivation were at one time twin industries, but whilst the latter has advanced, tea has been at a standstill for some years. In 1919 there were about 120,000 acres under tea owned by more than a million farmers. A common size for a tea garden is a quarter of an acre, but every farmer does not have his own factory.

Almost half the tea produced is grown in the Shizuoka prefecture, and the city of that name is the business centre of the industry. The second district is that of Kyoto with the neighbouring prefectures of Shiga, Miye and Nara. The only other tea district of any importance is in the Kumamato prefecture on the island of Kiushiu.

Practically all the tea made in Japan is green tea. The finest is known as Gyo Kuro (pearl dew), and is manufactured in the gardens round Uji, in the Kyoto district. The second grade is known as Sencha, and the third, which often includes the top prunings of the bushes, is known as Bancha. A trifling quantity of black tea is made. In 1919 the crop was made up as follows :—

Gyo Kuro	627,000	lb.
Sencha	59,592,600	,,
Bancha	21,336,800	,,
Black tea	419,700	,,
Total	81,976,100	,,

Most of the tea is kept for home consumption, the export figure amounting to less than 30 million lb. nowadays. The market for Japan green teas is mainly

in America and Canada, but here as elsewhere the taste is undoubtedly moving in the direction of black tea. Black tea made in Japan has not achieved any success to date. The failure cannot be ascribed to climate which compares with that of Darjeeling and parts of China.

Organization of the Tea Industry

Unlike the tea industry in China, that in Japan is well organized. This is due partly to the fact that the tea areas are compact and in country which is highly developed, and partly to the genius of the people. The Central Tea Association was formed in Tokio in 1883, under Government guidance, and since then Prefectural and District Associations have been formed.

The object of the central Association is to prevent the sale of inferior tea, to unify packing and so on, and to advertise Japan tea abroad by opening shops and by newspaper demonstrations. The district branches deal with local affairs.

At the principal stations and ports tea is examined for stalk, dust and water content. If it has a smoky flavour or any other undesirable characteristic its export is not allowed. In the district offices tea samples are examined for 'facing'. Teas 'faced' with small quantities of indigo have an improved appearance and are said to keep well. As small a quantity of indigo as 1 to 5 million parts of tea is sufficient for practical purposes. In order to test for 'facing', the tea is sieved through a 100-mesh sieve and the powder so obtained is rubbed on paper, which shows a blue mark if an excessive amount of colouring matter has been used. In such cases the tea is destroyed.

The Tea Association derives its income from various sources, the chief being the *kahyo* or ticket which must be affixed to boxes of tea when they are transported from

one district to another. Each farmer, manufacturer or merchant is bound to belong to the Association, and to pay a certain sum towards its upkeep.

In the city of Shizuoka, where the tea for export is re-fired and packed, there is an Association of Tea Firers.

At Kanaya, about twenty miles from Shizuoka, the Government tea experiment station was established in 1919. The station has good laboratories and a first-class factory, equipped for both machine and hand preparation. There is a much older station at Makinohara, about two miles from Kanaya, first established privately by several members of the district, and transferred to the Shizuoka prefecture in 1909. This station is now used for demonstration and educational purposes, rather than for research.

The Tea Crop in Japan

Some mention has been made in an earlier chapter of methods of planting, cultivation and manuring in Japan. The collection and nature of the crop will now be described.

The China variety of tea is planted in Japan. Plucking is carried out three and sometimes four times a year, the shoot consisting o f3 to 5 leaves and the leaf-bud. The first plucking is made in May and from this the best tea results. The second plucking is made about mid-June, and good drinking tea is then made. Both first and second pluckings make tea known as Sencha. The third plucking is made in July or August and the crop, a mixture of old and new leaves, is made into poor quality tea known as Bancha.

In the Uji district, the first tea, made from shaded bushes, is called Gyo Kuro. The second plucking teas are called Sencha.

Gyo Kuro is a tea with a sweet taste, best infused with water which has boiled and somewhat cooled. Sencha is best infused with boiling water. The first plucked Sencha is better than the second, plucked in the rainy month of June. Bancha is actually better than second plucked Sencha, except for the fact that the quality is reduced by the inclusion of old leaf. The manufacture of Bancha generally differs from that of the other pluckings in that it is steamed and dried without rolling.

The plucking periods and name of each plucking are now given.

Month	Plucking	Duration
May	First, Ichiban-cha	40–50 days
June	Second, Niban-cha	20–30 ,,
August	Third, Samban-cha	10–15 ,,
Sept. and Oct.	Fourth, Yoban-cha	10 ,,

Although the plucking may extend over many days, each bush is only plucked once in each period.

Yoban-cha, a grade favoured by some tea drinkers, is a thin liquoring tea of poor taste and flavour but with fair colour. The fourth plucking is not always made, for experiment has shown that over a period of years four pluckings give less crop than three.

The crop in Japan, although it averages under 700 lb. tea per acre, can be huge. In the Shizuoka district as much as 16,000 lb. green leaf, making somewhat less than 4,000 lb. tea per acre, has been obtained, but this is exceptional. In the open fields of Uji, as much as 2,800 lb. tea per acre may be expected, and somewhat

higher yields with shading. These values are taken from gardens growing for export.

Hand plucking has been superseded by plucking with clippers, although in Uji the farmers still try to pluck their first teas by hand. With hand plucking, 25 to 30 lb. leaf per day is a fair average, but with plucking shears from 200 to 250 lb. may be obtained by a woman and 300 lb. by a man. A maximum of 432 lb. has been plucked by one worker in a day.

The ease of plucking will be appreciated when it is understood that the tea bush in Japan resembles a box hedge with a continuous flush from the crown to the soil.

Pests and Blights

Japanese tea gardens are not troubled with pests and blights to the same extent as those in North-East India, a fact resulting partly from the severe winter. Most of the commoner tea blights have been observed in Japan.

Red spider is prevalent, especially if May is a dry month. It is treated with lime-sulphur solution. Green fly comes in June and after the second flush in July. It spoils the quality of the tea by making it taste more bitter than usual. Kerosene emulsion is used as an insecticide. The Japan hairy caterpillar does damage in July and October. An insecticide made from soap solution and powdered chrysanthemum is used. The Red borer does damage to the upper branches of the bush before April or May and is counteracted by cutting off the affected branches. The Tea looper appears in June, August and October. It lays its eggs in the bark of the pine tree and, in the vicinity of tea gardens where the pest is serious, the bark of such trees is stripped. The Faggot worm is collected in August. The Tea tortrix appears five or six times a year and no useful

insecticide has so far been found, but luckily there is a bee which devours the pest. The Tea mosquito is unknown.

Of the blights, Blister blight occurs at various times but usually in September or November. Brown blight appears after a too liberal application of manure. Shot Hole fungus, Red rust, Tea canker and Root fungus (*Rosellinia* sp.) are all known. The last is controlled by uprooting the diseased bushes.

Lime-sulphur and Bordeaux mixture are freely used by Japanese tea farmers who make up solutions in groups and use them together after the plucking season has finished. It has also been found advantageous to spray tea with Bordeaux mixture 20 or 30 days before plucking.

The Preparation of Japan Green Tea

Both the hand and the machine processes used in the preparation of Japan green tea will be described.

The Hand Process. The leaf is steamed as soon as possible after it is plucked. The steaming is carried on in a simple apparatus consisting of a vessel of boiling water covered with a cylinder fitted with a bottom of bamboo matting. About a pound of leaf is put into the cylinder which is then covered with a wooden lid. The leaf is submitted to the action of steam for a period varying from three to five minutes, according to the quality of the leaf. The better the quality the shorter is the steaming period. Too long steaming darkens the leaf.

The steamed leaf is thrown on a bamboo table and fanned in order to cool it as quickly as possible. In most factories this cooling is now done by an electric fan.

The rest of the preparation consists of rolling the leaf on a warm surface until it is too dry for further manipulation.

The rolling table consists of a shallow wooden tray, about 6 feet long and 3 feet wide, the bottom of which is

composed of paper about three layers thick, patched in innumerable places till little of the original paper is visible. Just under the paper is an iron plate, not near enough to rob the paper of its elasticity. The plate, which is warmed by a charcoal fire banked with the ash of rice straw, distributes the heat and prevents undue pressure on the paper.

At the Kanaya Experimental Station, leaf is rolled in about three hours and during this period one man deals with about 8 lb. fresh leaf. The temperature of the paper forming the rolling surface is about 240° F. With poor quality leaf the rolling may be completed in a shorter time on a warmer surface. The paper bottoms of the rolling tables can be heated to a temperature considerably higher than 240° F., although at 350° F. the paper begins to char.

The rolling process is divided into four periods. The first is called *Tuju-kiri* (dew removing) and lasts about 30 minutes. During this period the leaf is rolled very lightly and sometimes only shaken, so that although it dries, no juice is lost by expression. At the end of this period the leaf contains about 68 per cent moisture, having started with about 76 per cent.

The second period is called *Naka-age* (mid period) and lasts about 20 minutes. The roller himself does not work by the clock, but according to the condition of the leaf. During this period the leaf is rolled into balls, shaken loose and rolled again, and the moisture is reduced from 68 per cent to about 51 per cent.

After the second period comes an interval when the tea maker rests, the leaf is allowed to cool and holes in the paper bottom of the tray are mended. The rest period is about 15 minutes.

The third period, lasting about 45 minutes, is called the *Naka-mome* (mid rolling) and during this process

the moisture is reduced from about 51 per cent to 32 per cent.

The final rolling period, lasting about 30 minutes, is called *Siange-mome* (finish rolling) and by the end of this time the moisture is reduced to about 17 per cent. The hardness of the rolling must vary to a nicety with the moisture content of the leaf, for too hard rolling loses the lustre of the tea.

The final drying is carried out in a series of paper trays arranged one above the other. The heat comes from a charcoal fire banked with ash. The final drying takes about an hour and is done at a temperature of 160° to 180° F., the lower temperature being preferable. As the tea dries the trays are rearranged so that the drier tea goes to the cooler part of the drying case.

The best moisture content of tea for export is considered to be 4 per cent, although for home consumption it is dried to about 10 per cent.

Machine Manufacture. The following is a description of the factory procedure at the Kanaya experimental station, which is built and managed on excellent lines.

The steaming machine consists of a long flat box, about 6 feet in length and 3 feet in width. Through this box moves an endless wooden rack which carries the leaf. Steam is led into the box and the leaf is thus submitted to a temperature of about 200° F., which is considered ideal. About 5 lb. leaf packed about an inch thick passes through the box each minute, and such a machine can deal with about 2,400 lb. of leaf a day. As the leaf leaves the box it falls on a quickly moving paddle wheel which throws it through the air and cools it.

If the leaf is steamed too long it becomes dark in colour, pasty in rolling and makes poor tea. If the steaming time is too short, the colour of the leaf is green, which in itself is a desirable quality, but the leaf cracks

in rolling and the tea produced is poor in taste and aroma.

The rolling is carried out in four different machines which attempt to duplicate the motions of hand rolling. The first machine is called the *Soju-ki* (rough rolling machine) and imitates the light motion employed in *Tuju-kiri,* when the leaf is shaken and rolled lightly in order to dry it. The *Soju-ki* consists of a stationary cylinder about 4 feet long and 4 feet in diameter. Inside are three sets of springy, fork-like instruments, rotated by a central rod. The leaf is lightly thrown about by these forks and rolled against the sides of the cylinder.

Hot air is pumped into the cylinder by means of an electric fan, and the temperature is kept at about 160° F. At one time the heat was supplied by a charcoal fire, but it has since been discovered that the fumes from such a source are detrimental to quality.

The leaf is rolled in the first machine for about 30 minutes, and the moisture is reduced from 76 per cent to about 60 per cent.

The second machine is called the *Junen-ki* (twisting or rolling machine), and is similar to the roller employed in India. Very small machines are used, about 18 to 24 inches in diameter, and each roller takes 20 to 24 lb. leaf. The *Junen-ki* makes for appearance but not for quality. The moisture content of the leaf does not change during this process.

The third machine is the *Saikan-ki* (re-drying machine). This consists of a rotating box with stationary vanes which toss the leaf about and dry it. The temperature in the box is raised to about 115° F. by means of hot air, and the leaf is thereby dried to about 28 per cent moisture in 15 to 20 minutes.

The fourth machine is called the *Saiju-ki* (finish rolling machine). This consists of a long trough made of

aluminium and corrugated along its length. A wooden plunger, similarly corrugated, moves lightly backwards and forwards in the trough, rolling the leaf and keeping the individual leaves all end-on. The bottom of the trough is heated directly from below by means of a charcoal fire. By thus rolling the leaf at a temperature of about 160° F. for about 30 minutes, the moisture is reduced to about 11 per cent.

The leaf is finally dried in the same manner as that employed in the hand rolling process and thus, in an hour or so, the moisture content of the leaf is reduced to about 4 per cent.

In most machines iron is freely used with no detriment to the tea so long as the metal is hot.

At this point it is convenient to follow and compare the rate of drying of the leaf by machine and by hand manufacture. In order to make good tea the rate of drying should be regular.

	Machine manufacture	Hand preparation
	moisture %	moisture %
Fresh leaf	76	76
First roll	59	68
Second roll	59	51
Third roll	28	32
Final roll	11	17

Most tea farmers manufacture their tea partly by machine and partly by hand. It is common to machine roll till the leaf has a moisture content of about 50 per cent, that is somewhere near the *Naka-age* stage. Here it is possible to stop manufacture for a time as is done between the second and third periods in hand preparation. The later stages of manufacture are then done by hand.

Tea factories in Japan are all very small. The largest deal with about 12,000 lb. fresh leaf a day. It is common for a factory to deal with no more than 2,400 lb. to 4,000 lb. of leaf a day. The manufacturing periods are so short that larger factories are not economical, for with small factories the leaf has not to be carried far.

Many factories measure only about 36 by 25 feet, and in this small area there may be four rollers, two finishers, a rack dryer and a leaf steamer.

Practically all the factories, however small, are lighted and driven by electricity. In fact, the use of electricity even in the poorest cottages of remote villages in Japan is a matter for remark. The risk of fire is so great in the ordinary Japanese house, made as it is of the lightest wood and paper, that people are practically forced to use electricity for safety. Most of the electricity is generated by water power.

Some tea farmers buy fresh leaf from growers who have no factory. When they are open to do this, they signify the fact by flying a flag bearing a recognized sign.

Uji Teas

The Uji teas are the finest produced in Japan. The Uji gardens, dating from the twelfth century, have always been considered the best in the Empire, and the Uji tea known as Gyo Kuro is renowned.

In the months of April and May the country round Uji takes on an extraordinary appearance owing to vast stretches of artificial shading which covers the tea. The shading, put up about three weeks before plucking, is composed of grass and rice straw supported by bamboos at a height of about six feet. It is very dense shading and the sides of the area are also shaded. As soon as the first plucking is complete the shading is removed because it is injurious to the health of the bush.

The finest quality tea is made from the oldest bushes, and it was at one time considered that a bush needed to be 50 or 60 years old before it could yield good tea. Research has shown that 30-year old bushes can yield quite good tea, although that from young bushes, e.g. 10-year old, is poor.

In preparing Gyo Kuro tea, only about 4 ounces of leaf are steamed at a time, for 7 to 10 seconds. The rolling is done by hand at a low temperature. In very special cases the leaf may be rolled as long as 15 hours at a temperature of 140° to 160° F. The tea thus produced has a fine appearance but is poor in taste and aroma and has not the fragrance of a tea more quickly made.

The Japanese regard Gyo Kuro much in the same way as we look upon a wine of rare vintage. The tea is drunk slowly and thoughtfully from very small cups.

Farmers in the Shizuoka district attempt to improve their teas by shading, and it is a common sight to see individual bushes covered with straw in a manner similar to that in which a round haystack is covered. This covering holds back the growth and produces a tea of beautiful colour, but poor in flavour and taste. Such teas are useful for blends and are known as *Kabusei-cha* (covered tea). In some places considerable areas are shaded in the Uji manner, but the results are not the same.

The question of the material used for shading is one of importance. In Shizuoka only fresh rice straw is used, other coverings are considered to be inferior. The reasons underlying this practice have been studied and it is considered that the alkalinity of the straw may give the leaf a good colour.

Powdered and Patent Teas

Powdered tea or *Ten-cha* (milled tea) as the Japanese call it, is a ceremonial tea. It is cultivated in the same

manner as Gyo Kuro but the manufacture is different. Only the finest leaves are used, and these are picked over and separated from the stalk by means of chop sticks. The leaf is well steamed and not rolled, but dried in long, low drying rooms at a low temperature. As the leaf dries the coarser leaves are removed until only the finest remain.

Since powdered tea is very hygroscopic, the whole leaf is stored and is ground a short time before the ceremonial drinking. The powdering is done in a stone mill with care and slowness, and a great deal of ceremony.

Well boiled water which has been well cooled is used for making *Ten-cha*, for if the water is too hot the taste of the tea is bitter. The tea is stirred vigorously with a bamboo whisk, and is swallowed whilst still bubbling, powder and all.

Various patent teas are manufactured round the town of Uji and are packed in attractive tins for local consumption. One is a Milk Tea, containing both extracts of milk and tea, another is Lemon Tea. The most interesting product is *Cha-sei* (tea extract) which is sprinkled into hot water to give a liquor like freshly infused tea.

The details of the preparation of these patent teas are trade secrets. The tea extract is prepared from tea infusion which is evaporated *in vacuo* and centrifuged to remove the gummy matter. Unless the gums are removed, the tea extract will not powder well and is very hygroscopic.

Re-firing Tea for Export

Most of the tea for export is bought in the districts and is then taken to Shizuoka where it is re-fired by European and Japanese companies.

Tea may be re-fired in iron pans or in baskets. At one time re-firing was done by hand in small iron pans with 5 to 7 lb. tea at a time. Now the process is carried out in huge godowns containing batteries of pans, each capable of dealing with 15 to 30 lb. tea at a time. The pans are arranged in two rows, the front row lower than the back, and the stirring is done mechanically. First the tea is fired in the upper pans which are heated with coal or charcoal. After firing for about 30 minutes to an hour the tea is transferred to the lower pans which are cold. The stirring is continued in these pans and by this means a lustre is given to the leaf.

Formerly tea was 'faced' in the cold pans with Prussian Blue and talc.

The best teas are re-fired in baskets in the manner described in the chapter on China tea. The basket process is laborious and, as a compromise, the first part of the process is carried out in iron pans and the drying is then finished off in baskets. About three-quarters of the tea exported from Japan is pan fired.

Pan firing produces a broken tea, but in basket firing the leaf is little broken and contains whole shoots beautifully twisted into what are known as 'spiders' legs'.

The Quality of Japan Tea

In Japan green tea the colour of the leaf should be dark green. Light-green is the next best colour, followed by a blackish-green and then by a yellow. A brown or 'dead' colour, red and reddish-black colours are bad.

The colour of the infusion should be a greenish-yellow, but the green should not be too dense. Brown, red or dark colours in the infusion are bad. The tea must not taste bitter.

The scientists in Japan have observed that as a very general rule quality varies inversely as the tannin content and directly as the crude protein content of the tea. In many fine teas, however, the tannin content may be high. The amount of anthocyans and flavones in the leaf are of great importance.

Generally the tannin content of Gyo Kuro tea is about 9·5 per cent, as against 11 per cent to 12 per cent in a Sencha. An idea of the order of variation of the crude proteins with quality is given by the following. The average of a large number of Gyo Kuro of first, second and third quality gave crude protein values of 39·9 per cent, 38·7 per cent and 38·1 per cent respectively. The protein content of Sencha tea of the first plucking was found to be 33·7 per cent, of the second plucking 24·3 per cent and of the third plucking 24·4 per cent.

It has been shown that nitrogenous manuring increases the crude protein content of the leaf and also improves the quality of Japan green tea. Shading reduces the tannin content of the leaf and in this way helps in making the quality of Gyo Kuro.

Flavones and anthocyans are bodies which are chemically closely related, and the former may be converted into the latter by reduction with hydrogen. Flavones are yellow substances which give colour to a green tea infusion, but they are tasteless. Anthocyans taste bitter and are detrimental to quality. Shading reduces both flavones and anthocyans in the leaf. It has also been recorded that flavones vary inversely as the anthocyans in the leaf.

The scientists at Kanaya have worked out a simple test for the rapid estimation of the anthocyans in a green tea infusion, which is now used with confidence as an estimation of quality. The test is made as follows.

In a cup of 200 c.cm. capacity, 2·6 gm. of tea are infused for 5 minutes. To the infusion a few drops of dilute hydrochloric acid are added and, if anthocyans be present, a red coloration is obtained which varies in depth according to the amount of anthocyan. By means of a scale of standard colours the exact quantity of anthocyans in an infusion may be estimated at a glance.

Gyo Kuro teas give infusions free from anthocyans. So important are these substances as a factor of quality that even a tea poor in tannin and rich in crude proteins may be reckoned as lacking in quality if the anthocyan content is high.

The Grading of Japan Teas

Japan teas are classed as pan-fired or basket-fired according to the process used in re-firing. Pan-fired teas are broken in the process and are sieved to remove the smaller particles thus formed. These particles are then graded as Nibs, Fannings, Siftings and Dusts according to the coarseness or fineness of the particles. The sieved tea is then put through a cutting machine and again sieved to remove the smaller particles.

In basket firing, the whole leaf is retained if possible. The poorer grades of basket-fired teas, made from older, tougher leaf which will not take on a twist in rolling, may contain loosely rolled and even flat leaf.

Natural Leaf is a grade containing more coarse leaf than the other two types, and is usually pan-fired, although in some cases it may be basket-fired.

Nibs is the name applied to leaves and parts of leaves which during manufacture do not take on a twist. They are obtained from all grades of Japan teas, and when from the best give excellent cup results.[63]

TEA CEREMONY IN JAPAN

In Japan, tea making and tea drinking often take on a deep significance which is almost religious. Okakura Kakuzo in *The Book of Tea* writes on the subject as follows. 'Tea began as a medicine and grew into a beverage. In China in the eighth century it entered the realm of poetry as one of the polite amusements. The fifteenth century saw Japan ennoble it into a religion of aestheticism—Teaism. Teaism is a cult founded on the adoration of the beautiful among the sordid facts of everyday existence.'

In China, tea passed through several periods which may be roughly divided into three stages, the cake-tea which was boiled, the powdered-tea which was whipped and the leaf-tea which was steeped.

Japan closely followed Chinese civilization and knew tea in all its three stages. Tea is mentioned in Japanese history as early as 729, and in 801 tea was brought to Japan and planted at Yeisan and later, with greater success, at Uji. The use of steeped tea of the later China is comparatively recent in Japan, although now it has replaced powder-tea which is only used on ceremonial occasions, but still regarded as the tea of teas.

When Teaism was in its prime the tea room was a most important building, set apart from the house in a garden tastefully planted with shrubs.

The guests wash their hands before entering and leave their shoes and swords outside. They then enter the tea room before their host who kneels at the door. The guests in turn kneel before the *Tokonoma*, which consists of a low shelf let into the wall, and reminds one of an altar and forms the nucleus of the room. On the wall is a *Kakenomo* or hanging picture, which rolls up like a map when not in use. The subject of the picture

is something simple and austere and below it flowers may be arranged.

The host brings in the tea-making utensils and sets everything ready with much ceremony. When this is finished the guests retire and the host may arrange some fresh decoration in the *Tokonoma.*

When the water boils the guests are recalled by means of a gong, and food and *saké* are placed before them. Finally the powdered tea is taken from its silken bag and placed in the tea bowl. On it is poured hot, but not boiling, water. The mixture is frothed with a whisk and then passed to the chief guest who drinks it ceremoniously with a loud sucking noise. The bowl is then passed on and the others drink in turn. When the ceremony is finished the guests leave.

The greatest master of tea ceremony was Rikiu who lived in the sixteenth century under the patronage of Taiko-Hideyoshi. The enemies of Rikiu accused him of treason towards his patron and the tea-master was condemned to death, but was granted the honour of dying with his own hand.

The last tea of Rikiu is described in *The Book of Tea* as follows. 'On the day destined for his self-immolation, Rikiu invited his chief disciples to a last tea ceremony. Mournfully at the appointed time the guests met at the portico. As they look into the garden path the trees seem to shudder, and in the rustling of their leaves are heard the whispers of homeless ghosts. Like solemn sentinels before the gates of Hades stand the grey stone lanterns. A wave of rare incense is wafted from the tea room, it is the summons which bids the guests to enter.

'One by one they advance and take their places. In the *Tokonoma* hangs a wonderful writing by an ancient monk dealing with the evanescence of all earthly things.

The singing kettle as it boils over the brazier sounds like some cicada pouring forth his woes to departing summer. Soon the host enters the room. Each in turn is served with tea, and each in turn silently drains his cup, the host last of all.

'According to established etiquette the chief guest now asks permission to examine the tea equipage. Rikiu places the various articles before them, and after they have expressed admiration of their beauty he presents one of them to each of the assembled company as a souvenir. The bowl alone he keeps. "Never again shall this cup, polluted by the lips of misfortune, be used by man." He speaks and breaks the vessel into fragments.

'The ceremony is over. The guests, with difficulty restraining their tears, take their last farewell and leave the room. One only, the nearest and dearest, is requested to remain and witness the end. Rikiu then removes his tea gown and carefully folds it upon the mat, thereby disclosing the immaculate white death robe which it has hitherto concealed. Tenderly he gazes on the blade of the fatal dagger, and thus addresses it,

> Welcome to thee, O sword of eternity.
> Through Buddha and Dharuma alike
> Though hast cleft thy way.

With a smile upon his face Rikiu passed forth into the unknown.'

Tea in Formosa

Formosa or Taiwan is an island roughly oval in shape, about 220 miles long and about 90 miles at its broadest. It lies across the Tropic of Cancer about 90 miles from the coast of the Fu-kien province of China. A range of mountains runs down the length of the island,

north and south, leaving a broad plain on the western side.

The aborigines of Formosa are of Malayan stock and are now confined largely to the mountains of the centre and the east. The Chinese came to the island late in history, but they form the bulk of the population of the lower lands. After the Sino-Japanese War, Formosa was ceded to Japan in 1895, and since that date the resources of the island have been rapidly developed.

Tea was brought to Formosa by the Chinese and the Oolong process of tea preparation was introduced by settlers from the Fu-kien province. The tea is planted in the north end of the island in the prefectures of Taihoku and Shinchiku and, as in China and Japan, it is mainly in small patches, run by individual farmers. Of recent years Japanese firms have been operating on a larger scale, comparable with that in practice in India. At present about 120,000 acres are under tea and the annual production is about 27 million lb.

The tea is propagated by 'layers', for it is considered that plants grown from seed would not have the flavour which marks the Formosa teas.

The preparation of Oolong tea is as follows. As in China and Japan, tea for export undergoes two processes, the first on the garden and the second at a central factory. In preparing Formosa Oolongs the leaf is first placed in the sun to wither for an hour or two, and then in the shade to cool. Tossing and light manipulation follow and fermentation is thus induced, turning the leaves red and developing a fragrance. When the fermentation has reached a certain stage, short of that aimed at in black tea manufacture, the process is stopped by roasting the leaves in a pan.

Rolling follows, alternated by roasting. Then the leaves are dried in baskets as in black tea manufacture.

Chapter XI

NORTH-EAST INDIA

The geology of North-East India—Geography—Climate—Soils—Peoples—Communications.

In this chapter some of the natural features of North-East India are described. The geology is first dealt with, followed by the geography, the latter being mainly connected with the rivers which dominate the plains. The climate and soils, subjects touched on briefly in an earlier chapter, are here treated more fully.

In order to give an idea of present-day conditions in this primitive corner of India some mention is made of the peoples living within its borders, together with an account of the means of communication.

Outline of the Geology of North-East India

The tea areas of North-East India lie in and around two great valleys, those of the Brahmaputra and its tributary, the Surma. Most of the tea is planted either in the valleys or on the lowest foothills, and only in the Darjeeling district are the gardens actually situated in the mountains.

The Brahmaputra Valley is formed by the Himalayas on the north and the Barail range on the south. The latter is taken by geographers to include the Naga Hills or Patkoi range and the Shillong plateau. The Surma Valley is formed by the Barail range on the north and the Lushai and Chittagong Hills on the east and south-east where the valley becomes very broad as it opens to the Bay of Bengal.

The geology of North-East India is described in the *Memoirs of the Geological Survey of India.* Of recent years much detailed work has been carried out by the geologists employed in the coal and oil interests of Assam.

The Shillong plateau, comprising the Garo Hills, the Khasia and Jaintia Hills and the Mikir Hills, may be taken as the starting point of the geological history of North-East India. The core of this land mass is an ancient gneiss similar to that forming the Indian peninsula. At the end of the Jurassic period of geology, the Shillong plateau was at the head of a southern ocean of which the present Bay of Bengal was then a part. India was at that time joined to what is now Africa on the west and Australia on the east, forming an ancient continent spoken of by geologists as Gondwanaland. The southern ocean extended into what is now Upper Assam.

At the period of which we are speaking, to the north-west of what is now the Shillong plateau was one extremity of the Mediterranean Ocean of those days, spoken of by geologists as the Tethys. This ocean included a great part of the present Atlantic, most of what is now Europe, Tibet and the Himalayan region of northern India. The southern ocean was separated from the Tethys by a narrow neck of intervening land somewhere in the neighbourhood of the Shillong plateau.

In the Cretaceous period, which followed the Jurassic, the rock known as Cherra sandstone was deposited on the gneiss of the Shillong plateau. During successive upheavals and subsidences in the Tertiary era, about to be described, further beds of limestone, sandstone, shales and clay deposits were lain on the plateau which, throughout these widespread disturbances, stood firmly.

At the end of the Cretaceous period a new geological era opened, widespread changes in the earth's surface began and the land formation began to take on the characteristics which prevail to-day. The Eocene period, the first of the Tertiary era, saw the dawn of recent species, and witnessed the sinking of much of the land round the southern ocean and the separation of India from Australia and Africa. The raising of the floor of the Mediterranean Ocean followed and the lifting of the Tibetan plateau. Finally came the upheaval of the Himalayas.

Before the raising of the Tibetan plateau the country now occupied by the Brahmaputra and Surma Valleys was low-lying land between the two great oceans. This land was successively submerged and raised so that at one time it carried dense forest and at another was depressed and its vegetation covered by hundreds of feet of muds. The remains of this vegetation are now the coal measures of Assam, extending along the south of the Brahmaputra Valley from the Dehing to the Shillong plateau, although they once extended across what is now the Assam Valley itself. These coal measures are to-day laid bare in the Margherita and Sibsagar districts and also on the southern flanks of the Mikir Hills.

As the uplift of Tibet continued the muds and clays of the coal measures were buried beneath enormous gravel deposits brought down by the silt-laden rivers from the north, the ancient representatives of the Subansiri, Tsangpo, Dibong and Lohit, which poured in from what is now Tibet. These gravel beds stretched along a plain the width of Burma, bound on the east by the Miju range and limited on the west somewhere in the region of the Shillong plateau. It appears that the major portion of the great land mass extending into the

Bay of Bengal, now known as Burma, was laid down at this time from the spoils of the Tibetan highlands.

The next great change consisted of an uplift of the earth's crust, unattended by any great disturbance of strata. This resulted in the formation of the Himalayas in the north and the Patkoi range in the south. This upheaval was of a slow and quiet nature.

The deflection of the Brahmaputra and kindred rivers from the southern course across Burma to a westerly one along the base of the Himalayas had taken place with the initial uplift of the Patkoi. Between the Patkoi and the Shillong plateau is a break where now flows the Jetinga, and although the later deposits on the two ranges are the same, the core of the Shillong plateau is, as already stated, of ancient gneiss, whilst that of the Patkoi is of slates and sandstones of an indeterminate age, probably as young as Lower Tertiary.

Both the Patkoi and the Himalayas are in their later growth of contemporaneous development, and both are distinct from the mountain systems of Upper Burma, Tibet and western China. The termination of either range is at the head of the Assam Valley, where they meet the crystallines and metamorphics of the Miju range beyond Brahmakund, which lies at right-angles to the two lateral ranges.

The Tertiary rocks of the Patkoi include the Disang, the Coal Measures, the Tipam and the Dihing groups, named in order of their deposition. Rocks of the Tipam series form most of the hills round the southern part of the Assam Valley and round much of the Surma Valley.

To return now to the floor of the Assam Valley, at great depths this consists probably of the same gneiss as the Shillong plateau. Gneiss crops out at various places in the valley, notably at Tezpur, Bishnauth and

Silghat, and lower down the valley at Sorbhog. Even in the Dooars evidences of the old gneiss have been found.

The gneiss is overlain by an immense depth of alluvium. When the Patkoi appeared and the course of the Brahmaputra changed, the Tertiary sandstones overlying the gneiss must have been considerably eroded, but the almost entire absence of these rocks in the valley suggest a second depression, leaving the Brahmaputra to fill up the valley with its detritus. This new alluvium now generally forms a red loam, seen to-day in the Red Bank of the Dooars, the Bishnauth Red Bank and various places along the foothills. In many places, e.g. Nazira, Golaghat, the older alluvium just appears through the newer. Geologists, however, do not agree as to what is old and what is new alluvium, and indeed the valley has been so cut up by a network of streams all depositing sediment that it is often impossible to say which are Tertiary and which still later Quaternary deposits.

The Himalayan slopes are fringed with low hills of the Upper Tertiary period, consisting of sediment washed down from the crest line. These hills are known as the Siwaliks in northern India and stretch from the Indus to the Brahmaputra. In the Bengal terai and Assam these rocks are known as the Nahan series. Between the Teesta and the Raidak, in the Dooars, a distance of about 50 miles, there are no Siwaliks. In this stretch either clays, slates or shales of the Daling and Damuda series, or the new alluvium of the Red Bank separate the crystalline rocks of the Himalayas from the recent alluvium of the plains.

The centre and highest part of the Darjeeling tea district consists of Darjeeling or Sikkim gneiss, but the lower ends of the valleys which make up this area,

where they approach the Rangit and Teesta rivers and the Terai, consist of slates and shales of the Daling series. Where the district joins the Terai, the Daling, Damuda and Nahan series follow quickly upon each other.

The Surma Valley is bounded on the north partly by the Khasia and Jaintia Hills, a brief geological account of which has been given. The North Cachar Hills, which are part of the Patkoi, form the rest of the northern boundary, whilst the Lushai Hills and their offshoots bound the valley on its other sides. These hills are composed of Tertiary sandstones. Where the Shillong rocks with the Archaean core join those of the Patkoi, the change is marked. At Gujong, in the Mahur Valley, a few miles west of the hill section of the Assam-Bengal Railway, the recent deposits on the Shillong rocks are almost horizontal. In the Mahur Valley the change begins and at Guilong, on the east of the valley, the strata are almost vertical.

The *teelas* and spurs which run into the Surma Valley are Tipam sandstones of the Pliocene system. The alluvium of the plains is almost wholly derived from Tipam sandstones.

North-East India is a seismic area. The most notable earthquake on record occurred in 1869 and was attributed to a fissure about 20 miles long, situated at considerable depth below the surface on the northern border of the Khasia and Jaintia Hills. In 1897 a severe earthquake occurred, doing much damage to Shillong. Earth tremors are of common occurrence, sometimes causing considerable local damage. In 1917 damage was done in Sylhet, and in 1932 a continuous series of shocks was felt throughout Assam and the Dooars, the epicentre being near Dhubri.

An oil belt runs through Assam. Oil is worked mainly at Digboi in Lakhimpur, and at Badarpur in the

Surma Valley. The belt runs through Chittagong to the Arakan. The petroliferous beds occur in a series of rocks known as the Coal Measures which are supposed to form domes or anticlines cropping out beneath the newer sandstone and sometimes faulted against the older Disang series on the east.

As previously mentioned, coal occurs and is worked at Nazira and Margherita in Assam. Coal also occurs in small quantities and in powdered form in the Damuda series where they appear in the Terai and Dooars.

The Geography of North-East India

The tea districts of North-East India are included in a triangle, roughly equilateral, the corners of which are Darjeeling, Sadiya and Chittagong. The sides of the triangle are about 400 miles in length.

One side of the triangle running from Darjeeling to Sadiya, west and east, is formed by the Himalayas. The side running from Sadiya to Chittagong in a south-westerly direction is formed by the Patkoi and Lushai Hills. These two sides make a funnel facing towards the Bay of Bengal. Into the centre of the funnel, from the Patkoi, extends the Shillong plateau which separates the Brahmaputra from the Surma Valley. The side of the triangle from Chittagong to Darjeeling runs through the low-lying country of eastern Bengal, cut up by a network of waterways and subject to floods.

The tea districts fall into four areas, the Brahmaputra Valley, the Surma Valley, the Dooars and Terai, and the Darjeeling district. The first two areas are in the province of Assam and the other two in Bengal. The Chittagong district and Tripura are also in Bengal, and are geographically a continuation of the Surma Valley.

Although the Brahmaputra Valley is surrounded by high mountains, almost the whole area is flat, level plain.

Sadiya, near the head of the valley, has an altitude of only 440 feet above sea level, Dibrugarh 340 feet and Gauhati 163 feet. The Himalayas on the north rise abruptly from the plain to a height well above the snow line which is about 16,000 feet in these latitudes. The Naga Hills on the south average only about 4,000 feet in height, but reach 9,000 feet in places. The mountains are largely unexplored and are seldom entered by plains people.

The salient feature of the valley is the Brahmaputra. Hindu tradition describes this river as rising in the sacred pool at Brahmakund, about 50 miles east of Sadiya, but it has been shown that the Lohit, which comes from Brahmakund, rises in the Rima Valley where it is known as the Zayul Chu. The Dihang, which enters the Brahmaputra from the north just below Sadiya, has long been supposed to be identical with the Tsangpo of Tibet, and hence to be regarded as the main stream of the Brahmaputra. The explorations of Bailey and Morshead in 1913 from Assam by way of the Mishmi Hills to the head of the Tsangpo gorge practically proved this. The final gap of 30 miles in the course of the river was explored from the Tibetan side by Kingdon Ward in 1924.

When it reaches the plains the Brahmaputra runs between sandy banks in a wide strath, forming divergent channels which later rejoin the main stream. The stream is heavily laden with silt, although, the fall being greater than six inches to the mile, much of the finer sediment is carried on to be deposited in lower Bengal. The smallest obstruction in the river is liable to form an almond-shaped bank which, with the next flood, may be entirely deleted or grow to form a *chur* or island.

Dibrugarh is on the sandy bank of the river and is periodically in danger of erosion. The only other

towns of Assam which are actually on the banks are Tezpur, Gauhati and Dhubri, the last near the great angle where the river turns sharply to the south. These three towns are situated by outcrops of rock. Apart from the towns mentioned, the river meanders through a maze of sandbanks, sometimes thatch-covered. Old channels are often marked by a line of cotton trees. In the monsoon the river resembles a slowly moving lake, in parts as wide as five miles from bank to bank. Villages and tea gardens are usually remote from the river.

At one time the Brahmaputra flowed into the Bay of Bengal by its own channel, with the Barak or Surma river as a tributary near its mouth. The latter river, swollen early in the monsoon by torrential rain falling on the bare southern face of the Khasia Hills, occupies what was once the lower channel of the big river early on in the season. The Brahmaputra receives its flood from the jungle-covered hills in Assam which dole out water gradually and, as a result, this river rises about three weeks later than the Barak. Formerly the Brahmaputra flowed near Mymensingh, but year by year it was held up by the Barak, and each year it deposited silt in its own course on this account, and eventually ran along an aqueduct of its own formation. Finally the flow of the Brahmaputra, stemmed by the Barak floods and encompassed by its own sandbanks, left its course and ran across country to join the Ganges at Goalundo. The old course is now marked by a string of swamps and the Barak has sole possession of the lower course of what was formerly the Brahmaputra. This is one of the most interesting cases of what is known to geographers as river piracy.

The Brahmaputra receives several large tributaries in the Assam Valley, some of which enter the plains through Himalayan gorges of singular beauty. The Subansiri

is particularly notable in this respect. In the valley itself the tributaries usually flow between high banks and find their way circuitously to swamps and *bheels* near the parent river.

The Brahmaputra Valley is devoid of stone except near the Himalayas. The rivers coming from the Naga Hills have soft sandstone along their course near the hills, whilst those flowing from the Mikir Hills and the Khasia Hills bring down hard crystalline stones. The shortage of stone in the valley is largely responsible for the general lack of good roads.

Near the Brahmaputra is a belt of country from three to seven miles wide which is annually flooded. This is covered with high reed jungle interspersed with swamps. There is little cultivation in this tract except that of summer rice followed by pulse or mustard. The marshes or sandy *churs* left by the river form grazing land for buffaloes.

Away from this low-lying tract the valley is mainly occupied by village cultivation or by tea. The latter is put out on *bams* or banks which stand a few feet above the rice land, and on the lowest slopes of the Naga Hills. The hills themselves are clad in heavy jungle except where this is under *jhum* cultivation by the hill tribes. This type of cultivation consists of cutting the jungle and growing a crop on the hillside for a year or two, after which time much of the soil is lost by erosion and the land then deserted.

Although the scenery of Assam is beautiful near the hills, away from them it is dull and monotonous, consisting mainly of rice fields broken by bamboo clumps situated round very small villages. On the north bank of the river the Himalayas at certain distances are very striking and good views of the snows are obtained. Generally, however, the hills are invisible on account either of cloud or haze.

Most of the tea in the Assam Valley is put out between the Brahmaputra and the Naga Hills in the Lakhimpur and Sibsagar districts which together contain about 200,000 acres. The Lakhimpur district, growing the finest tea in North-East India, is steadily extending eastwards from Doom Dooma and a new sub-district in the Khamti country is in process of being opened up.

Whilst the bank of tea soils in the Lakhimpur district extends from the river to the hills in a belt about 30 miles wide, in Sibsagar most of the gardens are confined to the area near the hills. The Golaghat sub-district is partly situated in a bay between the Mikir and Naga Hills, shut off from much of the monsoon rain. This is a sun-baked, thatch-ridden area which, combined with the stiff nature of the soil, does not make for the best tea growth although the quality of the tea made is above the average.

To the west of the Mikir Hills, on the opposite face from Golaghat, is the Nowgong district, a small tea area containing about 10,000 acres. On the north bank of the Brahmaputra is the Darrang district in which about 60,000 acres of tea are planted. Much of the tea is put out on red banks well away from the hills, although some very recent alluvial deposits are also planted.

In the Surma Valley the tea districts consist mostly of long, narrow valleys running to the Barak or Surma. The valleys are formed by ranges of low hills, usually bamboo clad, which are thrown off from the main range. Innumerable hillocks or *teelas* are dotted over the valleys and these, together with the flats between them, carry the tea. In many instances the flats between the *teelas* have collected water which has been unable to get away and, as a result, a bog or *bheel* has formed which, on draining, grows vigorous tea.

Some account of the part the rivers play in the land making process which is steadily going on in Cachar and Sylhet is of interest. The main river, rising in Manipur, is known as the Barak in Cachar, the Surma in Sylhet and the Megna lower down in Bengal. When this river enters Cachar from the east it is a considerable stream overcharged with silt. As soon as the monsoon breaks, the small valleys which discharge into the Barak or Surma become swamps or *bheels*. As the big river receives freshets on its course it eventually rises above the level of the valleys lower down its course, and pours its own flood into them. As a result a thick muddy current, heavy with silt, passes into these valleys and swells the *bheels* into wide lakes. When the big river subsides, the streams again turn from the *bheels* into the Barak, having left behind a deposit of silt. With innumerable repetitions of this process the bottom of the district is raised and lakes turn into fens, fens shallow into reedy swamps, swamps into grassy prairies. Every stage in the process may be witnessed in any of the tea districts of the Surma Valley. With the rapid clearing of the jungle from the hillsides in recent years and the resultant greater risk of flooding, the silting up of *bheels* has become very rapid.

Within the narrow valleys themselves the rivers also bring silt from the hills and when the mouth of the valley is flooded these rivers back up and drop their deposit. As a result, most of the rivers flow between banks higher than the surrounding country.

At times serious floods occur. In 1929 several Cachar districts were so badly flooded that silt deposits several feet in depth, completely burying the tea, were laid down. These deposits were alkaline and even where quite shallow did harm to the tea. As the clearance of the jungle from the hills proceeds, and as the

bheels which act as safety reservoirs in times of flood fill up, liability to flooding will increase.

Hill Tippera or Tripura is geographically a continuation of south Sylhet, and is a small native state in which Europeans are not allowed to hold land. The tea in this state is accordingly held solely by Indians. Chittagong is contiguous with Tippera, still further south. The lie of the land in these areas is the same as in the rest of the Surma Valley, but climatic conditions are difficult owing to the severe drought.

The tea districts of the Dooars and Terai form a long narrow strip of land adjacent to the Himalayas. This area is cut transversely by large rivers, some of which are of the swiftest in India. The scenery of both districts is dominated by the Himalayan range, presenting a mountain mass capped by snow which can be described as majestic.

The river courses in this area may be divided into three sections. First there is the hill section where the stream is confined to a gorge or defile with its course fixed. The second division of the course extends from the debouchure where the river enters the plains till it runs in a definite bed. It is here that boulders, stones and gravel are deposited and it is into this porous bed that much of the water percolates to reappear as springs some miles away. The third division is where the springs appear and this part is known as the *terai* and carries dense jungle or grass according to its degree of swampiness. Lower down the river course becomes more defined and flows in a bed of raised banks of its own making.

The Teesta and the rivers in the Dooars find their way circuitously to the Brahmaputra. The water shed between the Ganges and Brahmaputra Valleys occurs a little to the west of the Teesta, and the Mahanadi, Balasan and Mechi, the rivers of the Terai district, belong to the Ganges system.

The tea gardens in the Dooars and Terai are in many cases planted in the *terai* section of the river courses and on banks which rise out of this area, not too far from the Himalayas on account of unfavourable climatic conditions away from the hills. Where low banks abut on the Himalayas these are put under tea, e.g. the Red Bank in the western Dooars (Mal, Chalsa and Nagrakata districts), the Hantapara plateàu and the Tertiary Nahan sandstones where they occur in the Terai (e.g. at Longview) and west of the Toorsa river in the Dooars.

The trees and type of jungle change with the land configuration. There are, broadly speaking, three types of jungle. First the sissoo (*Dalbergia sissu*) and khaira (*Acacia catechu*) forest, common on old river beds. The sissoo especially is able to thrive on poor sands. The second type of vegetation is savannah, a free growth of khagra (*Saccharum spontaneum*) interspersed with trees. On the *terai* areas where the water recedes to a great depth in the dry season this type of jungle occurs. The third type is met on the raised banks both near the Himalayas and in the *terai*, which are usually of stiffish soil able to retain moisture. The common trees here are the chalauni (*Schima wallistrii*), simul (*Bombax malabaricum*), saj (*Terminalia tomentosa*), cidha (*Lagerstraemia paviflora*), udal (*Sterculia villosa*), jamun (*Eugenia operculata*) and occasionally toon (*Cedrela toona*) and lampatia (*Duabanga sonneratoides*). The sal (*Shorea robusta*) is generally found on well drained soils intermediate between the richest and the poor sands.

The description of rivers given applies to all those flowing from the Himalayas to the Brahmaputra. On the south bank of that river, conditions are such that the *terai* belt is missing and a shorter rainfall modifies other conditions.

A DARJEELING TEA GARDEN
By permission of the Indian Tea Association

In the Himalayas there are limestone outcrops and the soil in the vicinity of such is likely to be alkaline and unsuitable for tea. The Dalgaon district is particularly liable in this respect and further along the Himalayas, in the Bishnauth sub-district of Assam, similar alkaline patches occur. No such conditions have so far been met in the tea areas on the south bank of the river, although limestone outcrops occur in parts of the Mikir Hills.

The Darjeeling tea area is a hill district and unique in this respect in North-East India. The tea is put out at various altitudes up to about 6,500 feet, although the average is between 3,000 and 4,000 feet. The tea district is a small rectangular area about 20 miles square surrounding the town of Darjeeling, the summer capital of Bengal. The latter is situated at a height somewhat under 7,000 feet, and commands an inspiring view of the snowy range of Bhutan, Tibet and Nepal, dominated by the Kinchinjunga group. The view of the snows is the more striking because of enormous range visible, extending from the Rangit Valley below Darjeeling at an altitude of about 2,000 feet, to the highest snows at about 28,000 feet.

The topography of the district is roughly as follows. The Singalila range of Nepal throws out a spur into the centre of the tea area at an elevation of 7,000 to 8,000 feet. From this water shed radiate seven valleys, giving to the Rangit on the north, the Teesta on the east and the Terai on the south. The tea gardens are situated on the flanks of the valleys and on the spurs projecting from the ridges between the valleys.

The Climate of North-East India

The year in north India may be divided into three seasons, the cool and dry lasting from November to

February, the hot and dry from March to June, and the hot and humid from June to October. As described in an earlier chapter, the breaking of the monsoon results when the low pressure area over central Asia is so marked that the north-east trade wind blowing to the low pressure belt at the Equator is overcome and its direction reversed. The strength of the monsoon varies each season and, although the ultimate cause of this variation has not been decided, it depends in part on the oscillations of the two winds pitted against each other.

When the monsoon current sets in, it splits into two main components to the west of Ceylon, one running up the east coast of Africa and the other round the Bay of Bengal. The African current sheds copious rainfall on the Abyssinian plateau which floods the Nile and enables the Egyptian crops to flourish in a permanently cloudless sky. After meeting the Abyssinian plateau the current makes an eastward turn, passing Cape Gardafui and the island of Socotra and, having lost practically all its northerly component, reaches Bombay almost from the west. The rainfall in Bombay is 150 inches but inland it decreases quickly. Arabia, Persia and Scind miss the monsoon, and Karachi has a rainfall under 10 inches.

The Bengal current is weaker than the African one. During its movement round the Bay it serves the southern part of Burma and then comes to Bengal. Both currents are influenced by a depression which occurs in Scind and Rajputana.

Towards the end of the monsoon period the Bengal current is caught up in cyclones which whirl it across India and the rainfall brought in this manner has a great influence on winter crops. Soon after, the cloud canopy is withdrawn from northern India and the cool dry season sets in.

It will be seen that North-East India is out of the track of the monsoon as it is understood in its narrower sense in India. Yet on account of the general drift of moist air towards central Asia, clouds pass over Bengal during the dry, hot season and throughout the monsoon period and enter the funnel formed by the Brahmaputra and Surma Valleys. Here they are shepherded round the hills till they are deposited as rain. On this account North-East India receives rain when the rest of northern India is in the grip of the fierce drought, and Assam is one of the permanently green corners in a continent where conditions are generally arid.

The topography of North-East India is such that the precipitation varies widely from place to place. The average annual rainfall is about 100 inches, but in some places in the Mikir Hills the figure is as low as 40 inches. On the other hand Cherrapunji, situated about 4,000 feet up, on the edge of the Shillong plateau facing south and overlooking the Surma Valley, is one of the wettest spots on earth, with an average annual rainfall of 381 inches and a maximum record of 905 inches.

It is impossible to say generally what rainfall is necessary for tea growth, since not only must distribution be considered but also the temperature during drought periods if they occur. Thus in North-East India the drought during the four cold months is not seriously felt. In April, however, a dry spell lasting only a fortnight may, in spite of rain earlier on, seriously damage the tea because of the high temperatures prevailing at this time of the year. Under conditions in Assam it may be said that about 60 inches annual rainfall is the minimum under which tea will succeed. An average near 100 inches is desirable.

Climatic conditions on the south bank in the Assam Valley are particularly favourable to tea, not only because

of good cold weather rain but also on account of the cold weather mists. These are wafted from the river by the north-east air drift to the areas on the south bank, and a thick blanket of mist rolls up before dawn and persists well on into the morning. Although these mists make conditions unpleasant for labour, they modify the effect of the drought in a manner beneficial to the bush. On the north bank and in the Dooars an early morning mist is a matter for remark. Cold weather mists are common in parts of the Surma Valley.

There are two distinct air drifts into North-East India, one by way of the Brahmaputra and the other by the Surma Valley.

In the Dooars the rainfall varies from 140 to 200 inches, thence up the Brahmaputra Valley there is a decrease about as far as Tezpur after which there is a general increase. The rainfall at Tezpur is about 70 inches and at Dibrugarh about 112 inches. One of the driest tea areas is that situated in the rain shadow of the Mikir Hills, a part of the Golaghat sub-district, where the average precipitation is only about 50 inches.

In the Darjeeling district rainfall is generally sufficient, and the drought effect is reduced by lower temperatures than in the plains. As might be expected in a hilly district, wide differences of rainfall occur within short distances. Places in the track of the rain drift have an annual precipitation of about 160 inches whilst in the rain shadow, a few miles away perhaps, only 80 inches may be recorded. The Himalayas form an effective rain barrier and deflect the air drift into Assam. The annual rainfall on the other side of the Himalayas, in Tibet, is only 8 inches.

Returning now to the other air drift, this passes from eastern Bengal, through the Surma Valley to the rain divide and then into the Assam Valley. Up to the

divide there is a steady increase in rain, after which there is a sudden falling off and rain is short till the leeway of the Mikir Hills is left and the Assam current picked up. These changes are illustrated below.

		Annual rainfall in inches
Chandpur (Eastern Bengal)	..	89
Habiganj (Sylhet) ..	..	99
Bikrampore (Cachar) ..	..	164
Nimotha (rain divide)	..	203
Lumding (Mikir Hills)	..	50
Golaghat (Assam Valley)	..	78
Sibsagar (Assam Valley)	..	96
Dibrugarh (Assam Valley)	..	112

From the beginning of May, rainfall is generally plentiful in all districts of North-East India. Before May, however, the drought is likely to be severe especially in the Terai and the Dooars.

The table below shows the average monthly rainfall at places in the tea districts of North-East India.

Table showing Monthly Rainfall in North-East India

	Doom Dooma, Assam	Tocklai, Assam	Silchar, Cachar	Mal, Dooars	Dar-jeeling
	in.	in.	in.	in.	in.
January	1·5	1·0	0·6	0·5	0·8
February	2·8	1·4	2·3	0·7	1·1
March	5·9	3·6	8·0	1·1	2·0
April	10·7	7·9	13·6	4·0	4·1
May	10·6	9·7	15·7	11·1	7·8
June	15·8	12·4	20·4	33·4	24·2
July	19·6	17·0	20·0	44·5	31·7
August	16·3	13·1	18·7	28·2	26·0
September	10·6	10·1	14·0	28·7	18·3
October	4·5	4·5	6·4	7·5	5·4
November	0·6	0·9	1·3	1·0	0·2
December	0·4	0·4	0·5	0·2	0·2
Total	99·3	82·0	121·5	160·9	121.8

The average monthly temperatures are shown in the next table. Those for Darjeeling cannot be taken as representative of many of the tea gardens which are often situated in warm valleys.

Table showing Monthly Temperatures in North-East India

	Tocklai		Silchar		Dooars		Darjeeling	
	max. °F.	min. °F.	max. °F.	min. °F.	max. °F.	min. °F.	max. °F.	min. °F.
January	70	50	78	52	75	46	47	35
February	73	53	81	56	76	49	48	36
March	79	60	86	63	84	55	51	42
April	83	67	89	69	87	66	62	49
May	86	72	89	73	89	70	64	53
June	89	76	89	76	88	74	65	56
July	90	78	90	77	89	75	66	58
August	89	78	90	77	89	75	66	57
September	88	76	90	76	89	74	64	56
October	85	71	89	72	88	66	61	50
November	78	60	85	64	84	56	54	42
December	72	51	80	55	78	47	49	37

Frosts are never registered in the tea districts of Assam, although they have been reported on rare occasions in parts of the Dooars.

Except during parts of March, April and May, the atmosphere is saturated each night in North-East India. The relative humidity is usually about 90 per cent at 8 a.m. and, as the day advances, falls to about 60 per cent or less in the dry weather. The absolute humidity shows a value of about 0·5 inches of mercury in January. In March or April it begins to rise and reaches a figure of about 0·7 inches. With the break of the monsoon there is a further rise to about 0·9 inches, at which figure it remains till the end of the monsoon, when it falls sharply

to about 0·5 inches in December. There is an appreciable direct correlation between the variation in the absolute humidity during the season and the tea crop.

In the cold weather the wind direction is generally from the north-east, whence it blows cool and dry. In December a depression often moves across India from Persia and brings what is spoken of as 'Christmas rain'. In the monsoon the air movement is from the south or south-west. The early months of the year are the most windy, and during March, April and May, hurricanes often blow, sometimes accompanied by hail. The latter contingency is often a real danger, for a hail storm may well strip a whole area of leaf and young shoots. The hailstones are often up to an inch in diameter and do great harm to the wood of the bush. Tea gardens liable to hail insure against such damage.

The amount of sunshine is an important climatic factor for it not only controls the air temperature but also influences the tannin content of the leaf and affects

	Wind, miles per day	Sunshine, hours per day
January	26	5·3
February	40	5·7
March	55	5·7
April	74	4·9
May	42	4·7
June	43	4·2
July	43	4·0
August	41	4·4
September	35	3·9
October	25	5·8
November	20	5·6
December	16	5·2

the incidence of some pests and blights. The solar radiation or sun temperature, as measured by a black bulb thermometer, varies between an average maximum of about 115° F. in January to about 155° F. in July. These values are independent of the air temperature, and are about the same for Darjeeling as for the plains.

The monthly wind and sunshine records for Middle Assam are shown in the foregoing table.

The wind mileage is that recorded by an anemometer erected at a height of 20 feet above the ground.

In North-East India it is observed that a wet, cold season is generally associated with severe Blister blight. A prolonged spring drought increases Red spider attack. In the Dooars a sunny spring is associated with a light attack of Tea mosquito, whilst in the Surma Valley the opposite is the case.

The Tea Soils of North-East India

In an earlier chapter dealing with tea soils in general, it was indicated that they may be classed as lateritic. Such a classification is not distinctive enough in dealing with soils of a limited area, so before giving examples of typical tea soils in North-East India some further observations on classification will be made.

The Government of Assam in assessing land values for purposes of taxation, divides the land into classes according to the crop it is capable of carrying. In Lakhimpur the classification is as follows :—

1. *Bari :* homestead, bearing fruit trees, etc.
2. *Daw-rupit :* transplanted rice land of low level.
3. *Bam-rupit :* land fit for transplanted rice, but of higher level than *daw-rupit.*
4. *Taklabari :* poor homestead land.
5. *Foringati :* high land unsuited to transplanted rice.

6. *Jalutak :* land subject to flooding and capable of bearing a precarious rice crop.
7. Tea land : all land taken up for tea cultivation.

Although this classification does not specify that tea land is unsuited to transplanted rice, this is actually the case. Transplanted rice land must be flooded during part of the season and such areas are unsuited to successful tea growth. High land, i.e. land above flood level, which carries jungle makes the best tea land, although grazing land will also carry good tea.

For some years in North-East India tea soils were classified according to their mechanical constitution, and a soil was shortly described by a string of figures. The method is illustrated below in the case of a common Sibsagar tea soil, mechanically analysed by Hall's sedimentation process.

	Fraction	Fraction number
	%	
Coarse sand	6	1
Fine sand	28	2
Silt	23	3
Fine silt	19	4
Clay	20	5

Soil class 2, 3, 5, 4, 1.

In denoting a soil class, the fraction numbers are put into a chain in order according to the magnitude of the fraction. Thus, in the above example, the fine sand fraction, denoted by number 2, is the biggest and takes first place in the chain. Silt, number 3 fraction, is the next biggest and so takes second place, and so on.

Although this system is a useful one it has drawbacks, the most obvious of which is the fact that soils of very different texture may fall within the same class.

In addition, this nomenclature does not appeal to the planter, who prefers to divide soils into three main classes: clays, sands and loams. The first two terms are self-descriptive, and a loam is a free-working soil, mainly composed of fine sand with some clay. Taken very broadly, it may be said that the predominant fraction in the tea soils of North-East India is fine sand and that most of the soils are loams.

In order fully to classify soils, some system which is based not wholly on the characteristics of the soil itself but also on its relationship to other factors such as geology, natural vegetation or crops, topographical position, etc., is necessary. In the American method of soil classification the unit is the soil *type*, which is a combination of a *series* name and a *class* (texture) name. For example, Sassafras Loam is the type in which Sassafras denotes the series, and loam the class.

Sassafras soils have definite characteristics and are capable of bearing certain crops. Thus the soil type describes both the general and particular qualities of a soil.

In determining a soil series the following characteristics are used as a basis. The geological origin of the soil material, the mode of formation, the topographic position, drainage and profile. The profile describes the soil at one, two and three feet depths. The description includes the colour, chemical reaction (alkalinity or acidity), organic matter and texture at these depths.

So far as the tea soils of North-East India are concerned there are a number of well-defined series. The Dooars Red Bank includes soils formed from the detritus of Sikkim gneiss and further weathered *in situ*. Another series is the Mal Sand, an alluvial soil deposited from Sikkim gneiss and found in the Terai, parts of the Dooars and some of the Darjeeling valleys. The Grey

Sandy Loams are alluvial soils formed from the rocks of the Daling series, and occur in the Dooars.

The Red Sandy *Teela* is a series formed *in situ* from Upper Tertiary sandstones of the Tipam series. These soils are common in Cachar, Sylhet and some Assam gardens which are put out on spurs of the Naga Hills. The Plateau soils of Cachar are generally stiffer than the *Teela* soils, and it is likely that what is now plateau was at one time washed from the North Cachar Hills to form a flat. Subsequent upheaval of this flat or subsidence or erosion of the lands to the south, formed the plateau.

In the Assam Valley two broad series of soils are distinguishable, the Old and the New Alluvium. The New Alluvium covers a whole range of deposits, the most recent of which are often grey in colour and poor in plant food below the top 9 inches. Some of the most recent deposits of New Alluvium are in the Bishnauth district of Darrang. Older deposits are found in the Jorhat district of Sibsagar, and yet older in the Doom Dooma and Dibrugarh districts of Lakhimpur. Even older deposits, still classed as New Alluvium, occur in the form of red banks which have had time to weather.

Whilst the grey soils are often poor sands or silts, low in acidity and at times almost neutral, the red soils are always strongly acid and are usually friable loams well supplied with plant food. In some places banks of yellow clay stand out of the grey alluvium. These are probably of more recent deposition than the red banks.

Many of the soils near the foothills of the Naga Hills are Old Alluvium, and some of the very low banks which crop out away from the hills also appear to belong to this series. In the Golaghat district banks of Old Alluvium are common.

Further remarks on the series just described are made in connexion with the examples given below.

The first table shows typical soils of the Brahmaputra Valley.

Typical soils of the Brahmaputra Valley

	Dibrugarh	Jorhat	Bishnauth
Mechanical analysis:	%	%	%
Coarse sand	16	5	56
Fine sand	34	55	24
Silt	12	18	11
Fine silt	15	11	2
Clay	17	6	3
Loss on ignition	5·9	2·9	3·2
Chemical analysis:			
Organic matter (Grandeau)	1·8	1·4	1·3
Nitrogen	0·10	0·08	0·08
Total phosphoric acid	0·09	0·04	0·06
Available phosphoric acid	0·015	0·008	0·011
Available potash	0·015	0·008	0·005
Available lime	0·16	0·016	0·038
Acidity (Hopkins)	650	500	300
Insoluble silicious matter	79	93	90

The Dibrugarh example is typical of the soils of the Lakhimpur district. These soils apparently have been laid down by the Dehing and Noa Dehing river systems and thus come from the Naga Hills. They show a lower percentage of insoluble silicious matter than the soils of the Jorhat and Bishnauth districts which were laid down mainly by the Brahmaputra. The Lakhimpur soils are deep.

The Jorhat soils are usually poor. The Bishnauth soils are often very light and the tea is liable to suffer from drought on this account, until it is well established.

The next table gives an example of a Darjeeling soil formed *in situ* from Darjeeling gneiss. The Mal Sand, Red Bank and Grey Sandy Loam are all from the Dooars.

Typical soils of Darjeeling and the Dooars

	Dar-jeeling	Mal Sand	Red Bank	Grey Sandy Loam
Mechanical analysis:	%	%	%	%
Coarse sand	23	64	19	5
Fine sand	10	16	10	31
Silt	13	4	12	29
Fine silt	27	7	18	25
Clay	20	4	33	6
Loss on ignition	6·8	4·8	7·8	3·5
Chemical analysis:				
Organic matter (Grandeau)	5·2	2·4	2·8	1·4
Nitrogen	0·18	0·12	0·12	0·09
Total phosphoric acid	0·09	0·081	0·15	0·16
Available phosphoric acid	0·018	0·019	0·014	0·06
Available potash	0·040	0·009	0·018	0·017
Available lime	0·05	0·02	0·028	0·15
Acidity (Hopkins)	840	150	800	120
Insoluble silicious matter	71	85	68	82

The Darjeeling soil is typical of many in this district, although many resemble the Red Bank shown in another column. The accumulation of fine silt appears to indicate a distinction for this class of soil. In the valleys of Darjeeling many of the soils are alluvial, resembling the Mal Sand and the Grey Sandy Loam. This last type is, however, rare, since only a very small area of tea in Darjeeling is planted on rocks of the Daling series.

The Mal Sands occur in the Terai as well as in the Dooars, and are alluvial deposits from Sikkim gneiss which have remained waterlogged and have thus collected plant food, in which they are now remarkably rich. The Mal Sands are generally dark brown or black, but in the south Terai examples of these soils are found on raised banks, well aerated, and the result is a red Mal Sand, much poorer than the average type.

The Red Bank soil may, in its general mechanical structure, be taken as typical of soils which are well weathered in North-East India. The characteristic is coarse and fine particles as major fractions, a combination not possible with water-borne, unweathered soils. The Red Bank soils, which are the richest tea soils in North-East India, generally abut the hills, although some isolated outcrops occur.

The Grey Sandy Loams are the newest tea soils in the Dooars, and as such are rich in lime and phosphoric acid. In some cases patches of alkaline soil occur, and here the tea is poor or fails altogether.

The following table shows analyses of Surma Valley tea soils.

Typical soils of the Surma Valley

	Teela	Flat	Bheel
Mechanical analysis:	%	%	%
Coarse sand	32	nil	nil
Fine sand	36	17	7
Silt	6	16	7
Fine silt	9	27	26
Clay	11	28	11
Loss on ignition	5·6	8·4	33·0
Chemical analysis:			
Organic matter (Grandeau)	2·4	3·7	20·4
Nitrogen	0·15	0·20	0·57
Total phosphoric acid	0·34	0·07	0·19
Available phosphoric acid	0·16	0·005	0·053
Available potash	0·13	0·014	0·036
Available lime	0·06	0·083	0·024
Acidity (Hopkins)	500	1,200	2,500
Insoluble silicious matter	92	75	55

The *teelas* or hillocks of the Surma Valley carry good tea although some of the southern and western slopes suffer from too much sun and from the drought.

The flat shown above is a common type of heavy clay, difficult to handle unless generously green cropped. The texture of soils from flats may differ widely from the example given, although they are generally heavy.

The *bheels* produce enormous crops, up to 2,000 lb. tea per acre. After 20 years or so they deteriorate, often owing to over drainage, as a result of which they lose their colloidal properties through repeated drying each cold weather, and become what is termed 'fluffy'.

The Peoples of North-East India

North-East India is situated between Burma, Tibet, Bhutan and Nepal, and is the home of many tribes. The ethnology of the area has received considerable study and is set out in an extensive series of monographs.

The mountains are peopled by primitive tribes who come to the plains in the cold season for purposes of barter, although a few years ago their visits took the form of raids. The Himalayas from the Dooars to Mangaldai are inhabited by Bhutias, and further east successively by Akhas, Daphlas, Arbors and Mishmis. The Miris occupy certain river areas in the Assam Valley. On the south of the valley the hills are peopled by various Naga tribes some of whom are still human head hunters when occasion serves. The hills of the Shillong plateau are occupied by Mikirs, Khasias and Garos. The aborigines of the valley, the Kacharis, live mainly in these hills. All these people are animists.

The present inhabitants of the plains of Assam are the Assamese, largely descendants of the Burman invaders who began to filter into the country in the thirteenth century and to dispossess the Kachiris who then occupied the plains. The Assamese are Hindus mostly, and are of Mongolian stock, as are also the hill tribes.

Assam suffered invasion by the Mohammedans from Bengal in earlier years, although the jungle acted as protection against any considerable advance from this quarter, since the invaders were not jungle folk. Of recent years the peaceful penetration into much of the best land of Assam by people from Bengal has proceeded steadily. Mymensinghis now occupy large tracts in Nowgong, Darrang and Kamrup.

Compared with other parts of India, Assam has little history, and what there is is largely centred round Sibsagar. The only buildings and works of merit now remaining are to be seen round this town in the form of temples and extensive earth tanks. None of these are of great age.

The heavy jungle and swamp, the ease with which the necessities of life can be obtained, perhaps the enervating effects of climate and malaria, all tend to make the north-east frontier of India a peaceful one in contrast to that of the north-west.

There is a steady flow of labour into Assam from other parts of India, for the Assamese seldom work on tea gardens and the hill tribes only do occasional work like jungle felling. Labour is recruited largely in Bihar and Orissa, the Central Provinces and Madras. Many of the labourers after a spell of work on the garden return to their country, but the rest either settle on the garden or acquire land in Assam of which there is plenty still available. These last consider themselves Assamese in the next generation.

In the Surma Valley the plains population is mainly composed of Mohammedans who originally came from eastern Bengal and are now known as Sylhetis. Of the hill people, the Manipuris and Lushais are the commonest.

The Dooars and Terai constitute what was once part of Bhutan and Nepal, although the natives of these areas

are Mechis. The garden work is done largely by Nepalis, but a great deal of labour is also imported from the plains of India. In Darjeeling most of the work is done by Nepalis and hill people. The Bhutias do not work on tea gardens.

Communications in North-East India

Although the Brahmaputra Valley is now well developed it is still a country where travel off the railway is difficult and slow. There are no hotels in Assam except in the hill capital of Shillong. The hills are mostly forbidden territory to the ordinary traveller.

Until the beginning of this century the main traffic artery of Assam was the Brahmaputra. A service of paddle steamers plies between Calcutta and Dibrugarh, a distance of about 1,000 miles which is covered in a fortnight. Certain districts on the north bank of the river, still beyond the railway, must use the river as their outlet.

In the Surma Valley the Barak was once the main line of communication and is still much used for the transport of goods and tea, as is also the Brahmaputra.

Communications in Assam have always presented a difficulty because of the sparse population, the unbridgeable rivers, the shortage of road metal and the torrential rain during the monsoon.

The first railways in Assam were the Jorhat Provincial, 2 feet gauge, and the Dibru-Sadiya, metre gauge, both built to connect tea districts with the Brahmaputra. The importance of the river as a means of communication diminished when the Assam-Bengal metre gauge line was constructed from Chittagong, through the Surma Valley, across the Barail range to the Assam Valley at Lumding, thence to Tinsukia where it joined the Dibru-Sadiya line. This outlet by way of the Barail range was partly a

strategic one. Unfortunately the course followed, although the most convenient, lay partly along the fault between the Naga and Jaintia Hills, with the result that landslips are common.

Later the line from Lumding to Gauhati was constructed and an alternative route to Calcutta made, although it was still necessary to take the river steamer from Gauhati to Dhubri where the Eastern Bengal line was joined. The last link in the railway between Calcutta and Upper Assam was formed when the line from Lalmonhirhat to Amingaon, opposite Gauhati, was opened in 1910. Transhipment across the river is still necessary at Gauhati, for the Brahmaputra is unbridged throughout its course. Many important branch lines have of recent years been constructed in Assam.

The Dooars is served by two branch lines which join the Eastern Bengal line at Lalmonhirhat. All these lines are metre gauge and when the Eastern Bengal line at Parbatipur is joined, it is necessary to tranship to the broad gauge, 5 ft. 6 in., line which runs from Siliguri, the station for the Terai, to Calcutta.

The Surma Valley is in direct communication with Chittagong which is an important tea port. To get to Calcutta from this valley it is necessary, however, to take a river steamer at Chandpur for Goalundo, thence the train again.

Regarding roads in the tea districts, those in the Assam Valley are usually very poor. Most of them are 'dirt' roads, which are either thick in dust or mud according to the season. Many places are isolated in the rains except for bullock cart traffic. Of recent years the use of graders has led to a steady improvement in the Assam roads.

The Ahom kings of Assam had a passion for road building and on both sides of the river long straight

earth roads, very often built on high banks above the surrounding swamps, can be seen. Many of these are still in use.

In the Surma Valley, laterite is available and some of the roads here are good on this account. In the Dooars and the Terai, plenty of metal is obtainable and the roads are excellent, although the rivers which cut the district transversely are difficult and expensive to bridge.

The Darjeeling district suffers the inconvenience of transport which is unavoidable in mountainous country. In most cases tea and goods have to be carried by coolies for considerable distances to the cart road or the Darjeeling Himalayan Railway, a 2 feet gauge line which runs from Darjeeling at a height of about 7,000 feet to Siliguri in the plains, where it joins the broad gauge line to Calcutta. Both road and railway follow the same line and rise to about 7,000 feet in just under 50 miles.

In the last ten years small motor cars have been used on the narrow tracks in the Darjeeling district, and this innovation has had considerable influence on the life of the planter who is no longer isolated from his neighbours by a long and tiring ride.

CHAPTER XII

THE DEVELOPMENT OF THE TEA INDUSTRY IN NORTH-EAST INDIA

The beginning of tea in India—Organization of the industry in North-East India—Statistics

BARELY a hundred years ago the presence of tea in the jungles of Assam was no more than a rumour, and the possibility of tea planting in that country was the dream of a few enthusiasts. By the end of the nineteenth century, the province, formerly one vast jungle penetrated by enormous rivers and broken only by a few clearances, had been opened up by railways, river steamers and roads of a kind. This development was almost wholly due to the tea industry. As China is the classic tea country, Assam, in the modern way, may be termed the romantic.

So far as tea itself is concerned, drastic innovations have been introduced in Assam. The China plant, which was first imported and grown, was abandoned for the Assam indigenous. China methods of hand manufacture were replaced by machinery, and distinct modifications in the preparation of tea were brought about. India tea as manufactured to-day is a commodity distinct from the China drink, being thicker, more pungent and more stimulating, although lacking the delicate flavour of the latter. India teas show distinctive flavours at certain seasons.

Not only was a modified product introduced from India, but India teas together with those of Ceylon captured and expanded the market in the United Kingdom,

A TEA FACTORY IN THE DOOARS

By permission of the Indian Tea Association

and to-day China teas are no longer in competition with the British product in the home market.

At present the tea area spoken of as North-East India, which includes the Brahmaputra and Surma Valleys, the Dooars, Darjeeling, the Terai and Chittagong, comprises about 640,000 acres, gives employment to about three-quarters of a million people and produces more than 300 million lb. tea annually.

The Beginning of Tea in India

The early history of tea in India is bound up with the history of the British connexion with the province of Assam.[65] Many Europeans who had had experience in Upper Assam during the early part of the nineteenth century knew that tea was growing in the country of the hill tribes (Singphos), at the north-eastern end of the valley, and was used for making tea by the Burmese method, by which the leaf is pickled. The fact was mentioned by Colonel Latter in 1815 and by Mr. Gardner in 1816.

In 1823 Mr. R. Bruce, an adventurer and trader, visited Garhgaon, near Sibsagar, for trading purposes and, having heard of the existence of tea plants in the neighbouring district from a Singpho chief, made arrangements to obtain some specimens. In the following year these arrived and were made over to his brother, Mr. C. A. Bruce, who was on service in charge of a flotilla of gunboats in Sadiya, on the Brahmaputra, in the Burmese War then in progress. The Burmans had been making raids into Assam and the Assamese had appealed to the British for assistance. In 1825, at the end of the war, C. A. Bruce settled in Sadiya and put

[65] Sir Ed. Gait, *A History of Assam*, Calcutta (1926). Sir Geo. Watt, 'Tea, and the Tea Plant,' *Jour. Roy. Hort. Soc.*, London (1906), 32. H. H. Mann, 'The Early History of the Tea Industry in North-East India,' *Bengal Econ. Jour.*, Calcutta (1918). C. S. Cohen Stuart, 'A Basis for Tea Selection,' *Bull. Jardin Bot.*, Buitenzorg (1919), 1, fasc. 4.

out most of the tea plants in his garden. A few specimens were sent to Captain David Scott, the first Commissioner of the newly acquired province of Assam, and he forwarded them to Calcutta for identification, together with supposed tea leaves he himself had discovered in Manipur. Identification was, of course, impossible without seed or flower, but the leaves were pronounced to be of the same family but not the same species as the plant from which the Chinese manufacture tea. Little attention was paid to the matter at the time, and the Bruce-Scott plant does not appear to have been preserved in any herbarium.

In 1833 the East India Company, having lost its monopoly of the tea trade with China, was anxious to obtain a rival source of supply under its own control. As early as 1780 a few shrubs had been imported from Canton and planted in Calcutta. In 1788 Sir Joseph Banks, the naturalist, at the request of the Company studied the problem and suggested Bihar and Cooch Behar as suitable areas for tea culture. At that time Assam was not included in the British Empire. The question of tea production in India was therefore not a new one when Lord Bentinck, the Governor-General, appointed a committee in 1834 to go into the matter. This committee issued a circular inviting all opinions which might be of any value as to where tea in India might be grown. At the same time the secretary of the committee, Mr. G. J. Gordon of the Calcutta firm of Mackintosh & Co., was sent to China to bring back plants and seed and also cultivators who knew how to grow and prepare tea.

The opinions obtained from the circular, based on analogies, often false ones, of climate and soil, convinced the tea committee that the proper places for tea cultivation were, in order of suitability, (*a*) the lower hills and

valleys of the Himalayas (indicating Mussoorie, Dehra Dun, etc.), (*b*) the eastern frontier and (*c*) the Nilgiris and mountains of central and south India. Exactly which area was denoted by the eastern frontier was not stated.

The circular had been received by Captain Jenkins, then in charge of the Assam Valley, stationed at Gauhati, who passed it on to Lieutenant Charlton, on service at Sadiya. As a result of this, complete tea plants, including seed and flowers, together with made tea, all obtained near Sadiya, were dispatched to Calcutta (on November 8th, 1834) and were identified with certainty as the same species as the China tea plant.

This re-discovery of tea in Assam caused a stir in interested circles in Calcutta. Dr. N. Wallich, then Superintendent of the Botanical Gardens, considered that, in view of the presence of tea in India, the importation of the China stock was a waste of time. Partly on this account Gordon was recalled from China, although not before he had dispatched several lots of seed to India.

In the meantime local progress had been considerable. Tea was discovered in the Manipur Hills, in Tippera and in new localities in the Assam Valley. Later, Lieutenant Charlton was called out to subdue a rebellion in which he was wounded, and had to leave the province. The experiments with the China seed were then taken over by C. A. Bruce who became the central figure in the local development of tea culture for a good many years.

In 1835 a scientific deputation was sent to Assam to report on the possibilities of developing the industry there. The deputation consisted of Drs. N. Wallich and W. Griffith, the latter a noted botanist, and J. McClelland, a geologist. The party reached Sadiya in 1836 and found the tea nurseries there, grown from the seed

sent from China, in a bad way, overgrown with weeds, suffering from cattle trespass and the poor soil. Of the 20,000 plants sent up from Calcutta only 500 were alive.

The deputation found tea in many parts of the valley, including Kutchu, Negrigram, Nadua, Tingri, Gabru-Purbat and Borhat, besides in the hills between Assam and Burma. No plants were found north of the Brahmaputra River and those found on the plains were always in groups, almost as if they had been planted. The Matak country, between the Dibru and Dihing rivers, was full of such groups. As the country had been desolated by war for many years it is quite probable that the tea bushes found on the plains had been planted. Only in the Singpho Hills did they become apparently part of the ordinary vegetation. Thus the question whether tea is indigenous to Assam was left doubtful, and so it has remained.

On some points, Wallich and Griffith had differences of opinion. The former considered the Himalayan region better for tea than Assam, but did not agree to the importation of China seed. Griffith favoured Assam, but considered the local plant to be a cultural variety of the China plant, and hence advocated the importation of plants and seed. Griffith had his way and, accordingly, Gordon was sent back to China for seed and plants.

In the meantime, in 1836, C. A. Bruce was made Superintendent of the Government Tea Forests and during the next few years did very fine pioneer work. In 1838 he published a pamphlet which included a map showing the extent of his discoveries of wild tea. In the Matak country he located 80 tea tracts, in the Singphos 12, and west of the Buri Dihing 28. The last were notably at Namsang, Tipam, Jaipur and in the neighbourhood of Rangpur (Sibsagar) and Gabru.

When the first seeds which were sent by Gordon arrived from China, they were sown in Calcutta early in 1835, and the young plants, 42,000 in number, were distributed between Assam, the Himalayas and the Nilgiris. The plants did well in the Himalayas, practically all those sent to the Nilgiris died, whilst those sent to Assam were planted on a sandy *chur* at Kundilmukh near Sadiya where, as previously mentioned, most of them failed.

Besides these ill-fated plants, a beginning was made with the exploitation of wild Assam tea, and in one case in order to 'work up or reclaim the Assam plant as rapidly as possible' (Griffith), wild and China tea were inter-planted. The experiment ended, happily, in the death of both varieties. Subsequent experience showed that neither the China plant nor a China hybrid does as well in North-East India as the indigenous plant. Meanwhile many jungle patches of tea were cleared with varying success.

In 1838 a new plantation of China tea was put out at Jaipur, and later one at Deenjoy, Chabua. A few of the original plants are said still to exist at Jaipur, planted 6 feet by 6 feet. At Chabua, the supposed original tea, now abandoned, can be seen planted in irregular lines. In 1838 or 1839, three more gardens were put out, one near Deohall, the second at Chota Tingri and the third at Hukanpukri.

The idea of those interested in tea in Assam was still to plant China bushes, but as these took time to mature, tea was first prepared from leaf plucked from indigenous bushes. The first tea good enough to send to Calcutta was made in 1836, although during this year and the next only small samples were produced. In 1838 enough was made for dispatch to England where it was awaited with great interest. At its sale in January, 1838,

it sold for an average of more than 20*s*. per lb., a price indicative not of its true value but rather of its novelty. All this tea was manufactured after the Chinese manner by imported Chinamen.

It had now been shown that tea could be made in Assam, and a number of capitalists approached Government, both in London and Calcutta, for the transfer of the Government plantations to themselves. A company termed the Bengal Tea Company was formed in Calcutta in 1839 and in the same year a joint stock company was also formed in London with a similar object, viz. the purchase of the East India Company's plantations and establishment in Assam for the purpose of carrying on tea cultivation there. The two companies almost immediately amalgamated as the Assam Company. In 1840 two-thirds of the experimental tea were handed over to the new company and C. A. Bruce was made superintendent of the northern division with headquarters at Jaipur. A man named Masters was made superintendent of the other division, with headquarters at Nazira.

Chabua was sold by Government to a Chinaman in 1840, but in 1851 it was taken over by Messrs. Warren and Jenkins who in the next year entered on the formation of the Maeejan Tea Barree. In the same year, Colonel Hannay, an officer whose efforts contributed much to the development of the industry, extended the tea area in his garden close to Dibrugarh.

To return now to the Assam Company, the earliest trouble was lack of labour which was not obtainable locally in sufficient quantity. Large numbers of Chinese were imported first, the supposition being that every Chinaman was capable of cultivating, manipulating and preparing tea. The experiment was a failure and the Chinese were described as 'turbulent, obstinate and

rapacious'. Labour recruited from India also proved unsatisfactory, largely on account of the unhealthy nature at that time of the country round Nazira.

In spite of these troubles the Company had 2,638 acres under tea in production in 1841, although the number of plants per acre was only 457. Most of the area consisted of groups of plants found in the jungle and cut down for cropping. The total amount of tea produced in this year amounted to 10,712 lb., but the cost of production was naturally enormous.

As might be anticipated, the first few years in the life of the Company witnessed many ups and downs. Owing to the isolation of the gardens from business headquarters in Calcutta, and also to lack of technical knowledge, many mistakes were made. Stephen Mornay as manager in Assam and Henry Burkinyoung in Calcutta were appointed in 1847, and these men took the Company from the verge of failure to success and stability. In 1852 this Company, the first tea company in India, paid its initial dividend, and from this time on the number of tea companies increased rapidly.

In 1848 the maximum crop per acre in the Assam Company was 275 lb. The biggest yield in those days was obtained in April and the season ended in September. The reason for this was that as soon as the leaf grew in the spring it was plucked, without giving any initial growth, in a manner similar to that employed in China. The monthly out-turn of the Company in 1848 was as follows :—

March	10,269 lb.
April	41,125 "
May	36,391 "
June	37,523 "
July	31,920 "
August	26,079 "
September	19,345 "

In 1853, George Williamson, afterwards founder of the firm of Williamson, Magor & Co., became the manager in Assam, and W. Roberts, afterwards connected with the Jorehaut Company, became the Calcutta managing director.

Williamson realized the evil of the China plant and also recognized that tea must be allowed to grow before it is plucked. When he put this latter discovery into practice, the directors became alarmed because of the crop shortage in March and April, but the result at the end of the year was a remarkable increase in crop per acre. Thus the problem of how much leaf to leave before plucking was opened, and is still the most difficult point to be decided by the manager on any garden. Too much or too little growth means loss of crop, and the latter also injures the bush.

The original holdings of the Assam Company were extensive and included large areas in the Tingri and Jaipur districts as well as land in Darrang (Singri Purbut) and Cachar. The Tingri and Jaipur areas were sold to the Northern Assam Company in 1863, and the Cachar division to Mr. Grob in 1864.

In 1859, Colonel Jenkins, then the Agent Governor-General of Assam, published a list of tea gardens established in Assam. This list included 30-odd gardens, most of the names of which are familiar to-day.

With the '60s, the pioneering days of tea in Assam may be said to have finished, although stormy and perilous days for the industry were still ahead.

Meanwhile, in 1855 indigenous tea was found in the Chandkhani Hills in Sylhet, and tea was put out in the Surma Valley, as the combined districts of Cachar and Sylhet are termed. Later on, tea was found wild along the Khasia and Jaintia Hills where they border the Surma Valley, and for some time the presence of

indigenous tea was taken as a sign that the area was suitable for tea growth. The first tea in Cachar was put out in Barsanjan in 1856, on the hilltops which stretch from the Barail range to the Barak river. The *teelas* (hillocks) were next planted out, and in 1875 the first *bheels* (swamps) were drained and planted. In Sylhet the first garden put out was Malnicherra in 1847.

About the same time Darjeeling embarked on the tea venture. By the end of 1856 tea had been cultivated at Tukvar, at the Canning and Hopetown plantations, on the Kurseong flats and between Kurseong and Pankhabari. After the industry had been established as a commercial enterprise in the Darjeeling district, attention was turned to the Terai where Champta was put out in 1862. The land east of the Teesta river was soon after explored and Gajaldhoba was planted in 1874, followed later by Phulbari (Leesh River) and Bagrakote. The tea area spread eastwards till it ultimately reached the Sankos, the boundary of Assam. The area between the Teesta and the Sankos, spoken of as the Dooars, now constitutes one of the most compact tea areas in North-East India. In the Terai and the western Dooars, China and China hybrid bushes were planted, but in the later gardens, planted further east, Assam varieties were put out. Of recent years the tendency has been to replace steadily the China bushes by Assam varieties.

The introduction of tea into Chittagong dates from the year 1840 when some China plants from the Botanical Gardens, Calcutta, and some seeds from Assam were planted in the Pioneer garden in Chittagong, near where the Club now stands. This district is not favoured with a suitable climate for tea and the industry has not made great progress there.

Organization of the Industry in North-East India

During the later decades of the nineteenth century many tea gardens were opened in Assam by individuals or as family concerns. Subsequent development has been mainly by limited liability companies. In the early days the length of the journey from England to India made it necessary to have a Calcutta agent to look after the business interests of the garden in India, and although improved methods of communication have removed the initial need for an agent the agency house system persists. The system gives the benefits of a steady policy in garden management and also makes for co-operation amongst sellers in shipping and marketing their crops. Most agency houses have also considerable holdings in the concerns they manage.

The Indian Tea Association, Calcutta, was formed at a meeting of Calcutta agency firms in 1881, the object and duty of the Association being to promote the common interests of all persons concerned in the cultivation of tea in India.

The Association started with a membership of companies and estate owners representing a planted area of 103,000 acres, which had increased at the end of 1926 to 523,840 acres. This area represents approximately 88 per cent of the area under tea in North-East India. In addition, each district has its branch association which deals with problems of local interest.

The Indian-owned tea concerns also have an association known as the Indian Tea Planters' Association, with headquarters at Jalpaiguri, in which district there are many Indian tea gardens.

The tea industry has an association for managing its labour affairs and for recruiting labour. As early as 1859 it was realized that the importation of labour was

essential, and a Tea Planters' Association was formed for the purpose, among others, of organizing a system of coolie emigration from Lower Bengal to Assam. The sudden expansion of the industry created a class of contractors who supplied labour to the tea gardens which were so rapidly being established. The planter had little to do with recruitment, and the results of this system were so disastrous owing to competition between contractors, that in 1861 Government appointed a committee to enquire into the system under which the emigration of labour was conducted.

As a result of this and other enquiries, various emigration acts were passed and finally, in 1915, recruitment by contractors was abolished. At present the only legal form of recruitment is done by headmen from the garden working under a licensed local agent in the district where they are recruiting.

In 1915 the Assam Labour Board was created to supervise the recruiting of labour on behalf of Government, and in 1917 the various planting associations connected with the supply of labour were amalgamated under the name of the Tea Districts Labour Association. It is estimated that the Association controls recruiting for 95 per cent of the gardens in North-East India.

The Indian Tea Cess Committee was constituted under an Act the object of which was to provide for the collection of a fund to be expended for the promotion of the interests of the Indian tea industry. From the year 1893 the Indian Tea Association had been collecting a voluntary assessment for expenditure on the development of foreign markets for India tea. There were, however, objections to raising money by this system, and the Association presented a memorial to the Viceroy praying for the imposition of a compulsory cess.

In 1903 the India Tea Cess Act was passed and a cess was levied at the rate of a quarter of a pie per lb. of tea exported (just over 2 annas per 100 lb.). In 1923 the rate was raised to 4 annas and in 1923 the Act was amended, again at the instance of the industry, so as to enable the cess to be levied at the maximum rate of 8 annas per 100 lb. tea exported. In 1923 the rate was raised to 6 annas, and in 1933 the levy of the maximum rate was suggested.

The cess is collected by the Customs Department and the proceeds are made over to the Cess Committee which represents the tea growers and the general commercial community interested in tea. The amount collected is shown below in a table which includes the amount collected in the initial year and in various other years. In the year 1931-32 the sum amounted to about £96,000.

1903–04	cess at	2	annas	per 100 lb.	Rs. 2,66,894
1913–14	,,	2	,,	,,	3,75,616
1921–22	,,	4	,,	,,	7,44,334
1923–24	,,	6	,,	,,	12,66,123
1931–32	,,	6	,,	,,	12,94,000

At the time when the cess was instituted the Committee determined to concentrate their efforts largely on the United States of America. The work could not be carried on during the War, but in 1923 it was again taken up with vigour.

In Continental Europe, work was started in a small way in 1905 in Belgium and Germany. The scheme steadily advanced till the outbreak of war in 1914.

In the United Kingdom the Committee carried on a scheme to counteract the propaganda in favour of China tea. In the last year or so efforts have been made to induce blenders to market British Empire blends.

During the War, work was started in India on a large scale. No direct trading can be undertaken by the Committee, but funds are spent in encouraging the sale of tea by private enterprise. Before the start of propaganda work in India the sale of tea averaged about 18 million lb. tea annually. The annual consumption at present is estimated at well over 50 million lb.

The Indian Tea Association has a well staffed and well equipped Scientific Department which deals with problems of tea culture and manufacture. The Department started in a small way in 1900 with laboratory accommodation in Calcutta. Later a laboratory at Heeleaka, near Mariani in Assam, was equipped. In 1911 the station was moved to its present site at Tocklai, near Jorhat, and from that date it has grown considerably. The expenses of the Department are met by subscriptions on an acreage basis collected from all companies in the membership of the Association.

Statistics

Below is shown the acreage under tea in North-East India compared with that in the other important areas which produce mainly black tea. No reliable figures regarding the area under tea in China are available.

	Acres
North-East India	640,000
South India	150,000
Ceylon	470,000
Java and Sumatra ..	371,000

The acreage in North-East India is steadily increasing, whilst that in south India is increasing rapidly. The Ceylon acreage is almost stationary, although a small area, variously estimated but probably in the neighbourhood of 20,000 acres, is still available for tea. The area in the Netherlands East Indies is rapidly expanding.

The tea area in India was distributed according to provinces in 1931 as follows :—

	Acres
Assam	431,004
Bengal	199,081
Tripura (Bengal)	8,552
Bihar and Orissa	3,642
United Provinces	6,254
Punjab	9,693
Madras, etc.	77,321
Travancore	71,886
Total	807,433

The small areas in Ranchi, in Bihar and Orissa, Dehra Dun in the United Provinces, and the Kangra Valley in the Punjab are collectively spoken of in tea as North India. Of the total acreage under tea in India, 77 per cent is in North-East India and 18 per cent in South India, as the tea areas in Madras and Travancore are styled.

The acreage in North-East India was in 1931 made up as shown below. The Brahmaputra Valley is considered to be that area of Assam east of Gauhati. The tea district called the Dooars is known officially as Jalpaiguri. The Darjeeling district includes the Terai

	Acreage	No. of gardens
Brahmaputra Valley	286,668	661
Cachar	55,340	175
Sylhet	88,996	162
Dooars	132,274	151
Darjeeling and Terai	62,731	169
Chittagong	5,829	26
Tripura	8,552	47
Total	640,190	1,391

where there are 20,000 acres of tea. On the market, Terai teas are sold with those of the Dooars and not with Darjeelings.

A small area of tea, 1,553 acres, in Purnea, Bihar, adjoins the Terai and is included in North-East India.

The total area occupied by tea concerns in North-East India is about two million acres. Much of the land included in tea grants is used for rice cultivation by the labour employed on the garden. Rice land is unsuitable for tea. In some gardens practically the whole grant is put under tea because it is all suitable. In such cases there is usually difficulty in keeping labour, who regard a plot of land for their own rice cultivation as essential. If possible, part of the grant is left for grazing and part under forest, grown mainly for fuel. The grazing land is for the cattle owned by the labour and such provision is very necessary. The labour force insists on keeping cattle, and unless grazing land is available the latter are driven into the tea at night to graze and serious damage results. Fuel is also grown largely on account of the labour, although on some gardens wood is used in the tea factory as fuel.

The growth of the tea area in Assam and Bengal is shown in the next table.

	Assam	Bengal
	acres	acres
Average 1885–89	211,301	73,169
Average 1900–04	338,250	136,153
1914	376,375	159,304
1924	412,859	181,833
1931	431,004	199,081

The total annual production of tea in North-East India has increased at a greater rate than the acreage. This increase in yield per acre has been marked in the

Assam Valley and the Dooars and very slight in the Surma Valley. The next table shows the total output from Assam and Bengal at certain periods.

	Assam	Bengal
	million lb.	million lb.
Average 1885–89	66·68	19·38
Average 1900–04	141·11	48·71
1914	208·55	75·37
1924	237·15	87·12
1931	243·23	88·48

The total output in North-East India in 1931 was about 332 million lb., of which under a million lb. was green tea. In 1917 the production was 350 million lb. and in the slump year of 1921 only 242 million lb.

Tea is exported from Calcutta and Chittagong. In 1931-32 Calcutta dealt with about 217 million lb. and Chittagong with about 78 million lb. South India ports dealt with about 47 million lb. The difference between production and shipments is a measure of the amount consumed in India.

A study of the yield of tea per acre in Assam and Bengal over the past 50 years is instructive, since it

	Assam	Bengal
	Tea per acre in lb.	
1885–89	316	265
1890–95	358	292
1895–99	361	330
1900–04	416	362
1904–09	477	425
1910–14	531	468
1915–19	614	554
1920–24	527	423

illustrates the steady increase up to the end of 1919, followed by a fall. This last was due to the post-war slump when an accumulation of stocks forced the adoption of finer plucking. Since that date the yield has not been back to the 1915-19 average. The average yields taken over 5-year periods are shown in the foregoing table.

The next table shows the yields of individual districts in North-East India in 1931 :—

	Yield per acre in lb.
Lakhimpur	764
Sibsagar	612
Nowgong	559
Sylhet	551
Darrang	535
Jalpaiguri	534
Cachar	480
Darjeeling	345

Each district produces tea of some distinctive character or peculiar merit, although no sweeping statements can be made to include all the teas of a district. Darjeeling teas bring the highest average price, followed by those of Upper Assam. Surma Valley teas average the lowest prices in North-East India.

The market value of teas is constantly changing, as is also the absolute and percentage difference between the price of teas from various districts. Any definite figures are therefore of little use as a guide to values, especially during the past few years when slumps and booms have been constantly exaggerating or minimizing differences. The characteristics of the teas from the various districts are as follows.

Upper Assam teas are valued for pungency and quality, and at some periods of the year for flavour and

appearance. The second flush and autumnal teas are flavoury, and the earlier teas are often a blaze of 'tip'.

Middle Assam teas, which include those of Sibsagar and Darrang, are of medium quality, although here and there a garden in these districts may produce teas equal to the best.

Dooars teas are thick liquoring at certain times of the year, and give flavour in the autumn which is much sought after. This flavour sometimes resembles that of the Darjeeling teas. The latter have very marked and highly valued flavour in the second flush. The Terai teas are usually light and sweet, characteristics which are often observed when China bushes are grown in the plains. There are considerable areas of such bushes in the Terai.

Cachar and Sylhet teas are usually designated as common, and are at times inferior to those of other districts, although in appearance they are often attractive. When market conditions are such that fine plucking and careful manufacture are called for the teas from these districts can be as good as most and superior to many of the so-called medium teas of the Assam Valley. At other times it is said that the Surma Valley teas lack the character of those of the other valley.

The relative position of India in the export tea trade is shown in the next table. This trade has undergone great changes, and the past 50 years have witnessed the eclipse of China as the first tea exporting country, and the advance of first India and Ceylon and then the Dutch Indies to prominent positions in the trade.

In the table below, the figures in brackets indicate the percentage change in the size of the exports. The figures for China include black, green, brick and tablet tea, whilst those for India include the teas exported from all districts.

Table showing tea exports in million lb.

Year	India	Ceylon	China	Dutch Indies
1896–97	150·4 (100)	110·1 (100)	240·1 (100)	—
1905–06	216·8 (144)	171·3 (156)	152·9 (76)	25·7 (100)
1915–16	292·6 (194)	208·1 (189)	205·5 (86)	98·0 (382)
1924–25	348·5 (232)	204·9 (186)	102·1 (42)	105·1 (410)
1931–32	348·3 (232)	244·0 (222)	95·7 (40)	145·3 (566)

Although the average area of the tea estate in North-East India is about 460 acres and a common size is 1,000 acres or more, such estates are referred to as gardens. In Ceylon and South India the less attractive but more dignified name of estate is used.

CHAPTER XIII

THE CULTURE OF TEA IN NORTH-EAST INDIA

Clearing the land—Tea seed gardens and tea seed—Nurseries and planting out—Pruning—Plucking—Cultivation—Manuring—Pests and blights.

CLEARING THE LAND

LAND carrying jungle is the most sought after for tea planting, although large areas of grass land have been successfully put out. Low-lying land, unless capable of drainage, does not do well. New gardens are nowadays often put out as extensions of existing ones, and when they have reached a sufficient acreage are supplied with a separate staff and factory. Sometimes gardens are opened out several miles from other plantations. In such cases the manager first selects a site for the coolie lines, builds himself a simple house, and sets the labour to clearing the jungle and planting out nurseries with purchased seed. People of the hill tribes can often be obtained for felling the jungle. Apart from this there is always a migration of labour to a new garden.

When the jungle is felled it is burnt off in the dry weather. The tree stumps are usually left to rot in the ground, and the bigger trunks may either be left to rot where they fall or rolled into depressions and left. As an alternative the trunks may be collected and burnt in a pile, although the alkaline ash so formed may account for a weak patch of tea later on. In five or six years little evidence of the old jungle remains, so rapid are the agents of decay in their work. In the meantime, however,

the presence of logs and stumps holds up planting in certain places.

The ideal would be to take out all stumps and to carry away all logs, for dead wood encourages fungus disease. In opening out a new garden the natural tendency is to clear and plant as fast as possible. Accordingly, not only is much wood left, but it often happens that planting proceeds more rapidly than labour can be assembled to cultivate and tend the plants put out.

After two or three years, when the young plants require plucking, the nucleus of a factory is built, with a view to later extension. At the end of a decade the garden is probably working in full swing.

It will be understood that mechanical cultivation is usually out of the question in opening up a new area, not only on account of the presence of heavy timber but often on account of the broken nature of the land. On parts of the north bank of the Brahmaputra where thatch land is planted, tractors are used before the tea is put out. When the bushes are fully grown there is no room for a mechanical cultivator to work between the rows, although many attempts have been made to adapt existing machines to the purpose.

Tea Seed Gardens and Tea Seed

Tea seed is usually grown in small areas attached to tea gardens. North-East India, with its dry, cold weather is particularly suited to the formation and ripening of seed, and in most districts are seed gardens of repute, from which are annually dispatched much seed to the tea-growing countries of the world.

Some of the best and most successful seed gardens are planted out as follows. The bushes are planted 10 feet by 10 feet square, and centre pruned when about four years old. After about ten years, alternate diagonal

rows of bushes are cut out, leaving the planting 14 feet by 14 feet by 20 feet triangular. The stems of the bushes are kept clean and are sprayed with lime-sulphur solution to a height of about 5 feet.

The seed pods are collected after they have fallen, and are placed in damp shallow sand pits, covered with grass, for a few days, after which the pods are easily removed. After shelling, the seed is placed in a water tank, and of those which sink a certain number are split and examined. If the sinkers are more than 90 per cent sound and 'unstarred', they are dried and packed. If they show less than 90 per cent sound they are put back into the pits for four or five days and then refloated and a fresh test made of the sinkers.

The light seed or floaters are also split and examined, and if they contain less than 50 per cent good seed they are burnt. If there are more than 50 per cent good seed, the floaters are put back in the pits for four or five days and then again tested in the tank. In the meantime some of the floaters will have become sinkers, and these are tested as described above.

The sinkers which have passed the test are dried for a few seconds in the sun and the cracked seed removed. Cracked seed is capable of growing good plants, but is not usually packed and sold. Seed is generally packed in fairly dry powdered soil or charcoal or a mixture of both.

Light-leaved seed trees yield about 5 maunds (400 lb.) seed per acre per annum, and dark-leaved about double this quantity. The crop is collected in the late autumn.

In order that seed may be imported from India, the Governments of some importing countries insist that it shall be free from certain diseases, and before seed is allowed in, a certificate from the Scientific Department of the Indian Tea Association, which guarantees such

freedom, is necessary. In some cases the certificate must be covered by one from the Director of Agriculture of the province.

The seeds are tested as follows. A fair representative sample of the consignment is taken, and of this each seed is cracked open and the number 'starred' noted. The 'star' is the result of a puncture by the tea seed bug (*Poecilocoris latus*) and actually consists of a small quantity of starch left by the bug after it has extracted its food from the seed. A drop of iodine solution is placed on the 'star', and if it turns a uniform blue colour no further examination is made and it is assumed that the only damage done to the seed is that resulting from the puncture. If the least part of the 'star' fails to turn blue, then the seed is examined microscopically for fungus diseases.

Although a 'starred' seed may germinate well and give a good plant, a puncture in the seed is serious in that it provides a possible entry to fungus diseases, eelworms and mites. It is, of course, possible that these organisms may enter through the micropyle (eye of the seed) but only a few instances of infection without a puncture have so far been recorded.

It follows from the above that the best way to ensure sound seed is to control the tea seed bug. If mature seed is punctured, the puncture must have been made after the seed had set in the shell, after the jelly-like substance in the seed had become solid, so that attention to the seed bug during September and October will reduce the percentage of 'starred' seed. A seed punctured before it has set is hardly likely to ripen, a fact which makes control of the pest a necessity at all times of the year.

Grey blight, Brown blight, Die-back and Eelworm are the organisms pathogenic to tea found in punctured

seed. Blister blight and Green fly have not been found. Fusaria, bacteria and moulds are the non-pathogenic organisms found.

It is not known to what extent, if any, the pests and blights found in tea seed may be passed on to the plant. The failure of nurseries at times may be due to Die-back in the seed, and the presence of Eelworm in nurseries may also result from infected seed, but these points have not been proved.

Nurseries and Planting Out

Before planting nurseries it is preferable to germinate the seed, although in practice this is not always desirable because of the extra supervision entailed. Germination does not ensure better plants but a more even nursery. The seed is generally available in November or December and the nurseries should be put out as early as possible.

The nursery bed is usually made in a small clearance in the jungle, conveniently near the area to be planted. The soil is thoroughly cleaned but not hoed too deeply, otherwise the lifting of clods when the seedling is transplanted is difficult. The seeds are planted at distances varying from 4 to 10 inches square, according to the age at which the plants will be lifted. Experiment has shown that if 6-month old seedlings are to be transplanted, the seed should be 5 inches apart in the nursery; for 12-month plants, 8 inches in the nursery; for 24-month plants, 10 inches in the nursery.

The seeds are planted about half an inch deep, with the eye downwards. This latter is an important point, because a straight tap root is necessary to a good tea plant. If the tap root is not sound or is cut in transplanting, it is likely that when the bush matures it will be a poor leaf yielder.

The seed bed, which is usually about 5 feet wide, is well drained and shaded, either by the surrounding jungle or by artificial shade consisting of a grass mulch or of overhead shading supported by bamboos. Shade about five feet high gives the best results. In a season starting with a severe drought a nursery may be a total failure unless it is shaded, and even in a good year shading pays handsomely. Shade is sometimes provided by dhaincha (*Sesbania arcuata*) grown near the beds during the first spring. Nurseries may be treated with liquid manure with advantage.

Tea seedlings are generally replanted when about 8 to 14 months old, and only selected plants are removed from the nursery. The plant is lifted intact with a clod of earth. If the clod is broken during lifting or in transit, the plant is discarded, otherwise it is carefully carried to the clearance where a hole has been dug for its reception. When areas are being replanted or vacancies infilled it is usual to add a basket of cattle manure to each plant.

For planting new areas, 8- to 12-month old plants are preferable, but for infillings or for replanting old tea lands, older plants are often used with advantage.

In North-East India the usual distance for planting on the flat is 4 feet 6 inches triangular, which gives 2,483 bushes per acre, or 4 feet 6 inches square, which gives 2,150 bushes per acre. With such planting the plucking surface of the bushes can be made to present a continuous expanse from 6 to 10 years after planting. On *teelas* it is common to plant on the terraces in rows at a distance of about 3 feet.

There are about 16,000 tea seeds in a maund (80 lb.), and about four or five acres of tea, less than 13,000 plants, can be planted from this number of seeds. The deficiency is accounted for by bad seed and weakly seedlings.

Pruning

The young tea plant is made into a bush by one of two methods. The first is to let it grow for two or three years and then to cut it between one and four inches above the ground. By this method a secondary or coppice growth is induced and the bush takes on a spread. This method was at one time popular in Assam, but has of recent years been discarded to some extent. The other method is to cut the plant straight across at a height of about 18 inches and to remove one or more of the central branches. By this means the frame of the bush is made and a spread obtained without cutting thick wood.

For giving a big crop in the early years, centre pruning, as the latter method is called, is certainly preferable to collar pruning. After collar pruning, the next cut is made one or two years later at a height between 6 and 18 inches. The lower the cut the wider the frame of the bush, but the greater the delay in getting crop.

At least 90 per cent of the tea on established gardens consists of formed bushes which are top pruned yearly or every other year. The object of top pruning is to remove the foliage and weakly twigs, and to cut the bush back, leaving about one inch of last year's wood. Thus each year the woody portion of the bush gets higher, until the latter is too high to pluck. When this is the case the bush is heavily pruned.

Heavy pruning is a difficult problem. In Upper Assam it is common to cut the bush right down to the ground at intervals of about 20 years, and to build up a new frame again. In other districts it is the custom to cut the bush where the spread is fairly broad, back to thick wood. In this case the bush sends out shoots from an inch or often much more below the cut and a

dead piece of wood remains on the branch. These dead snags form entry places for fungus diseases which may kill the entire branch and eventually the bush. The more healthy the bush the less likely are snags to form, and on this account it is advisable to prepare the bush for the operation by manuring and by light plucking the season before cutting back.

In many districts it is usual to leave a large part of the garden unpruned each year. Thus when the bush stops flushing in November or December, it is left till the following March or April when the spring flush appears, and is then plucked again without leaving any new growth above the plucking table.

The advantages from unpruned tea are several. The crop is gathered early, before the garden labour wants leave for its own rice cultivation. The first leaf from unpruned bushes makes good tea as opposed to the poor tea given by 'tippings' from pruned bushes. A grave drawback to unpruned tea is the risk of severe early drought, in which case the unpruned bush, carrying full foliage, suffers badly. Unpruned tea is more liable to fungus attack and Red spider than is pruned tea.

It has been shown that the best method of managing unpruned tea is as follows. In the pruned year a good growth is allowed before plucking, perhaps as much as 12 inches, which means that practically no early crop is made off the bush that season. Next season all the leaf is plucked as it appears, so that by July or August a big crop has been made, and the unpruned tea can then be left, if necessary, and the labour concentrated on the pruned areas.

Tea cannot be left unpruned indefinitely, for with each season unpruned the leaf becomes smaller and more difficult to gather, and flower is produced at the expense of leaf. In addition, to leave a bush unpruned is a

strain on the plant, and one year of such treatment is considered enough at a time.

Although the use of unpruned tea reduces the pruning costs and provides work for the labour in the early part of the season when otherwise there would be little garden work to do, the gain in crop from biennially pruned tea over tea pruned annually is small over a period of years. General experience shows that the fullest benefit in crop is obtained by leaving tea unpruned every third or fourth year, rather than every other year.

In Darjeeling, on account of the slow growth, it is unprofitable to prune annually, and a four-year cycle is common. In the first year of the cycle the bush is top pruned, in the second it is left unpruned, in the third it is 'skiffed' and in the fourth year it is again unpruned. In the following year it is pruned just above the last cut, made four years previously. The cycle may be lengthened to five or even six years.

It sometimes happens that whilst it is inadvisable to leave an area unpruned, it is undesirable for some reason to prune it. In such a case the tea is 'skiffed' or 'switched'. This treatment consists in cutting the bush across level just below last season's plucking marks. By this means the foliage is reduced and an earlier crop is obtained than if the area had been top pruned. After 'skiffing' it is usual to pluck above one leaf at the 'tipping'.

Top pruning in North-East India is best done in December or January, and should be followed by cultivation in which the prunings are buried. If pruning is postponed till later, crop is lost. In a normal year early pruned bushes may be 'tipped' early in April, but a late pruned bush is not ready at this time and accordingly loses crop which it fails to make up later in the season.

The best time to collar prune fully grown tea in North-East India is about September, when the food stores of the plant are plentiful, but pruning at such a time would entail the loss of half that season's crop, a fact which makes such a procedure rare.

PLUCKING

It is common in North-East India to pluck shoots of two leaves and a leaf-bud, although often three or four leaves are taken if the object is to make a large crop rather than fine tea.

In Middle and Upper Assam it is usual to fix on a plucking table, and to take all shoots of two leaves and a bud which appear above that height. The plucking height is seldom below 27 inches from the ground, and often much higher. On tea which has been medium pruned, at least 9 inches of new growth is allowed before plucking, provided that such an allowance brings the plucking table to a height of not less than 27 inches. On a top pruned bush it is usual to leave about 6 inches growth before 'tipping'. This length is equal to about three leaves' growth in the centre of a vigorous bush of the Assam variety.

In some districts, notably the Dooars and the Surma Valley, it is considered that the method of plucking adopted in Assam is too severe for local conditions. Accordingly, after the 'tipping' the bushes are allowed to form a fresh plucking table, one or two leaves higher than that made by the first plucking. In the third flush the table may again be raised, and in some gardens the bush is not plucked to the *janum,* level with the previous plucking, till August. The bush thus gets higher as the season advances.

The lighter the plucking the healthier is the bush, although the crop may be smaller for a period, at any

rate, than that given by harder plucking. It is generally considered in the Brahmaputra Valley that strong tea, well manured, can be hard plucked, i.e. 'tipped' on a six-inch growth and then plucked to the *janum,* without becoming sickly.

The advantage of not plucking the side branches of the bush till they grow level with the plucking table at the centre of the bush is now realized. By letting the sides develop a greater plucking surface is obtained, and eventually a bigger crop is harvested than is possible by plucking the sides below the level of the centre. Another advantage resulting from allowing the sides to grow is that the soil is thereby shaded and weed growth retarded.

In North-East India the bushes begin to flush with the spring impulse in March or April and the 'tipping' is made at a definite height. The second flush comes in June, and the teas then made in Upper Assam are well supplied with 'tip'. This is probably because the pruning in this area is severe, and the early shoots thereby produce fat buds which expose a great deal of 'tip' on rolling. Unpruned tea and tea which has not been cleaned out in the pruning gives little 'tip'.

There are, broadly speaking, six flushes in the season in North-East India, although the bushes are plucked every week if labour is available. After the second flush, which is very definitely marked, the others may be indistinguishable so far as a definite rise and fall in the crop is concerned. This is because after the early flushes, shoots growing from axils below the plucking table are constantly reaching the plucking level and make for a continuous supply of leaf.

Autumn teas usually possess flavour which brings high prices. The flavour is believed to be due to the slower rate of growth at this period. In mid-season a shoot takes about three weeks to develop from the leaf axil

after the shoot above has been plucked. In the autumn the same growth may take as long as six weeks.

Quality teas can only be made from fine leaf, and whilst the economics of fine and coarse plucking are beyond the scope of the present discussion, it is useful here to state what is considered a fine pluck. A sample of fine leaf gathered in the height of the season should comprise shoots in about the following order.

10	per	cent	one leaf and a bud (large)
65	,,	,,	two leaves and a bud
15	,,	,,	soft single *banjhi*
5	,,	,,	three leaves and a bud (small)
5	,,	,,	soft double *banjhi*

If the bushes are plucked every six or seven days and everything taken that appears above the plucking table, this standard can be achieved. In the early part of the season the percentage of *banjhis* should be much smaller than shown above, although at some parts of the season it may be much greater.

The composition by weight of the average tea shoot plucked in North-East India is shown below.

Bud	14	per	cent	of	weight	of shoot
First leaf	21	,,	,,		,,	,,
Second leaf	38	,,	,,		,,	,,
Stalk	27	,,	,,		,,	,,

A shoot of three leaves and a bud weighs about twice as much as a shoot of two leaves and a bud.

Cultivation

In Assam the hoe with a long handle is used for cultivation. In districts where the soil is stony a fork hoe is used, whilst in Darjeeling the soil is turned with an English fork.

Tea planters early recognized that the cleaner the soil is kept the greater the crop, and the idea grew that

cultivation or 'tincture of steel', as it was popularly designated, should be the first consideration in garden operations. A deep hoe to a depth of 6 or 9 inches was put in during the cold weather, and a light hoe to a depth of 3 or 4 inches once every month or so afterwards.

With the shortage of labour during the past few years a monthly round of hoeing became impossible, and in the rains the weeds often got ahead of the cultivation by August, and sometimes completely engulfed the bushes. It was then gradually realized that the beneficial effect of frequent hoeing was due to the removal of the weeds rather than to the disturbance of the soil. Accordingly, other means were sought to control weed growth, and to this end the practice of leaving the sides of the bushes in pruning became customary. In this way the weeds are kept in check by the shade given by the bush and by this means an area of fully grown tea can be kept reasonably clean with four or five well distributed rounds of light hoeing a year.

In addition to hoeing, it is usual to fork round the collar of the bush once a year in order to remove ferns and grasses which collect there and escape the ordinary weeding. Forking is also valuable in keeping down termites and in turning over chrysalids, which should be destroyed. In this way some control of caterpillar pests is possible.

Trenching was at one time largely practised, but now very seldom. Both trenching and deep cultivation cut the roots of the bush and in this way are harmful. In addition they are unnecessary unless there is a soil pan which requires breaking up.

The question of soil erosion is an important one in Darjeeling and on the *teelas* of the Surma Valley. In Darjeeling it is common to plant the slopes closely and to rely on weeds to stop soil wash. Cultivation is given

before the rains break, and during the wet season the weeds are sickled. This procedure has proved highly successful in retaining the soil on the steepest slopes. In the Surma Valley the *teelas* are terraced or contour planted.

Manuring

The systematic manuring of tea in North-East India is a comparatively recent innovation. The first manuring was top dressing from *hullahs* or *bheels*. Later on cattle manure was used, although only within the last 15 years or so has this valuable manure been carefully stored in properly constructed pits. The use of oilcake followed, and then animal meal. There has always been a preference shown by planters for organic manures, and only recently has the free use of chemical manures become common.

The tea soils of India require frequent additions of nitrogenous manures and organic matter. From extensive field experiments it has been observed that applications of potash or phosphatic manures alone give little or no crop increase. On sandy soils, nitrogen is best applied with potash and on clays with phosphoric acid.

Nitrogen is the chief factor producing vegetative growth, i.e. leaf and wood, and is the main constituent of all mixtures given for increasing the tea crop. It is usual to add about 30 lb. nitrogen per acre per annum, usually as sulphate of ammonia, although much greater quantities than this are often added. Nitrate of soda, calcium cyanamide, cakes and meals are also used. Unit cost is usually the main consideration in choosing a manure.

The early addition of a chemical nitrogenous manure produces a vigorous spring flush, and is considered by many planters to be responsible for a falling off in second

flush flavour. In fact, many practical men, both producers and buyers, consider that of recent years teas have shown a falling off in quality, which they attribute largely to the excessive use of artificial manures. Certainly heavy doses of nitrogen depress the tannin content of the leaf and in this way make for thin liquors, and it is quite possible that in some way the substances that make for flavour are affected by heavy or unbalanced manuring.

Phosphoric acid makes for root growth and promotes the formation of root nodules in leguminous plants. It hastens maturity and tends to cause a plant to complete its life cycle rapidly. It tends to promote flowering and is hence a useful manure for seed gardens. Excess of this manure on tea may lead to the early 'wooding up' of the young shoots, and early flowering, particularly with China and hybrid plants. There is also some evidence that excessive phosphoric acid may increase the stalk in tea.

Basic slag and superphosphate are often used on tea gardens, and bone products and rock phosphates are also in common use. Here again the choice of the manure generally depends on the unit cost.

Potash assists in filling sound seed and hence may not be neglected on seed gardens. It lengthens the period of vegetative growth, and thereby gives a longer flushing period, and helps to keep unpruned tea flushing. In the case of many plants it increases the resistance to disease, but no evidence in this respect with regard to tea is available.

Potash is usually added as the muriate, although the sulphate and nitrate are at times used.

Of recent years there has been a tendency to omit both potash and phosphoric acid from manurial mixtures, but opinion is now turning in favour of using balanced mixtures as being less likely to interfere with quality.

Organic matter is added to the soil as cattle manure, if it is available, or as green crops. The expense and difficulty of collecting cattle manure is so great that its use is limited.

During recent years green crops have been freely grown. Those used are either 8-week crops or semi-permanent. Of the former, dhaincha (*Sesbania arcuata*), cowpeas (*Vigna catiang*), mati kalai (*Phaseolus* spp.), sunn hemp (*Crotalaria jauncia*) and soy bean (*Glycine hispida*) are in general use. They are planted in the spring and hoed in in May or June before the heavy plucking months. When planted in every row, 30 to 40 lb. seed per acre are used, and a good crop is 3 tons per acre.

Of the semi-permanent crops, rahar (*Cajanus indicus*) is sown in every second or third row and buried at the end of the season. Boga medeloa (*Tephrosia candida*) is left up two years, and indigofera, commonly used in Darjeeling, is left up three to five years. With these crops a yield of about 5 tons greenstuff per acre may be expected.

Many gardens at present manure in cycles such as the following :—

1. Rock phosphate and an 8-week green crop, or 5 tons cattle manure per acre.
2. Chemical mixture giving 30 lb. nitrogen and 30 lb. potash per acre.
3. Rahar or boga medeloa and chemical mixture forked round bushes, giving 30 lb. nitrogen, 20 lb. potash and 20 lb. phosphoric acid per acre. The rahar is cut and buried at the end of the season.
4. Chemical mixture as in 3.
   The boga medeloa is buried at the end of the season.
5. Chemical mixture as in 3.

In actual practice it is usually impossible to grow a ground green crop satisfactorily in mature tea and, in its place, a chemical mixture is given. The manures are added in the spring.

The manuring of seed gardens is different from that of tea since the crop here is seed, not leaf. Accordingly, a big dose of phosphoric acid and potash is given in August when the seed begins to fill. Nitrogenous manures are given in the spring.

Lime is practically never used now. The history of its use and disuse is an interesting one. The earliest advice given by scientists was based wholly on the practical experience of planters, and was against lime. Then the reaction of the tea soils of North-East India was studied and the question of acidity taken up. In other parts of the world it has been shown that soil bacteria responsible for nitrogen fixation function best in an almost neutral or alkaline soil. Since the tea soils of North-East India were found to be strongly acid, the use of lime in small doses was advised (800 lb. per acre every 5 years). Although some practical men discarded this advice and refused to add lime, in many gardens it was used and in some cases in large quantities. In the meantime field experiments were begun, and in 1925 sufficient results were available to show that lime was harmful to tea. Later it was seen that a dose even as small as 800 lb. depressed the crop over at least the six following years, while large doses of lime killed young tea.

These discoveries led to the abrupt disuse of lime, although in the decade or so over which it had been employed much money and crop had been lost and, in some cases, persistent heavy liming had seriously crippled gardens.

Shade trees are grown amongst the tea in most gardens, partly for the benefit of the shade and partly

for the manurial value of the leaf droppings. They are usually planted 30 feet to 40 feet square, but as the trees develop planting at this distance is often found to be too close. About 50 feet apart is recommended for most districts. Too dense shade lowers both quality and crop. Shade is needed mostly during the spring months, and more especially where the light leaved varieties of tea are grown.

The most common shade tree is the sau or black sirris (*Albizzia stipulata*), a quick growing tree which unfortunately easily cankers. The Ceylon sau (*Albizzia moluccana*) is not popular because of the dense shade it retains in the cold weather and its consequent heavy call on the soil moisture reserves. The white sirris (*Albizzia lebbec*), the koroi (*A. procera*), bor medeloa (*Dalbergia assamica*), the sissoo (*D. sissu*) and the *Derris robusta* are in common use. The dadap (*Erythrina* spp.) was at one time popular but is not now planted because when it dies the stump brings fungus diseases to the surrounding bushes.

All the trees mentioned, except the Ceylon sau, lose their leaves in the cold weather and some do not take on foliage till May or June.

Tea on any soil, even good virgin soil, responds readily to manures. Without manuring, crops of 15 maunds per acre are common when the soil is good, but after about 20 years the crop tails off. Eventually a minimum crop of about 6 maunds per acre is obtained and this can be maintained without manuring. On tea gardens where there are vacancies and weak patches, the crop usually falls to about 5 maunds per acre when manuring is omitted for a number of years.

Shade is capable of adding 2½ to 3 maunds per acre to the crop, so that without any artificial manuring it is possible to get about 8 maunds per acre. Steady

manuring at the rate of about 30 lb. nitrogen per acre will raise the crop of good tea to about 12 maunds per acre.

Pests and Blights

In North-East India, the two worst tea pests are the Tea mosquito and Red spider, although numerous other pests do more or less damage at certain seasons.

Among the Orthoptera, crickets (*Branchytypes portentosus*) often give considerable trouble, more particularly in nurseries and heavily pruned tea.

Of the beetle pests of tea (Coleoptera), the most important is the Orange or Peal's beetle (*Diapromorpha melanopus*), which by eating partly through the succulent shoot of the flush causes the upper portion to die off. Cockchafer grubs (*Lachnosterna* spp.) attack the roots of the plant and may do considerable damage to nurseries.

The Shot Hole borer (*Xyleborus fornicatus*), so obnoxious in Ceylon is, fortunately, unknown in North-East India.

The list of caterpillar pests (Lepidoptera) of the tea plant is a long one, amongst which those of the Faggot and Bag worms (*Clania* spp.), Bark-eaters (*Arbela* spp.), Red slug (*Heterusia magnifica*), Red borer (*Zeuzera coffeae*), Looper (*Biston suppressaria*), Bunch caterpillar (*Andraca bipunctulata*), Sandwich caterpillar (*Agriophora rhombota*), Leaf rollers (*Homona menciana, Grecilleria theivora*) and Nettle grubs (*Thosea* spp.) are the most important. The caterpillar of one moth (*Blastobasis spermogena*) lives inside the tea seed. It may be noted that all the caterpillar pests turn into moths, and up to the present no butterfly pest of tea is known.

No member of the Hymenoptera is known to be an actual pest of the tea bush, though ants of various

species, by protecting scale insects and tea aphis, contribute indirectly to the damage done.

The order Hemiptera includes the insects which occasion most concern to the tea industry. The Tea 'mosquito' bug (*Helopeltis theivora*), the arch enemy of the tea plant, occurs in practically all districts, but is particularly dangerous in the Dooars, Terai and the Surma Valley. The pest when severe may cause the bush to stop flushing entirely. Green fly (*Empoasca flavescens*) is credited with producing a stunting effect on the shoots but at the same time improving quality. The Tea aphis (*Toxoptera theaecola*), by curling and stunting the young growing shoots, may cause considerable check to young plants in the nursery and to bushes beginning to grow after pruning. Scale insects do a considerable amount of damage in the hill districts of Darjeeling, though in the plains the more vigorous growth of the bushes reduces the damage done by these insects. *Chionapis manni*, in particular, does much damage in Darjeeling by sucking the downward stream of sap from the branches and so causing the branch to be starved below the point of attack. Thus a branch half an inch in diameter above this point may be only an eighth of an inch in diameter below it, and the growth of the bush is seriously impaired. The Tea mealy bug (*Dactylopius theaecola*) which attacks the roots of the plant is also a noteworthy pest of tea in Darjeeling. The Tea seed bug (*Poecilocoris latus*), whilst scarcely affecting the plucking bush, is a serious pest in tea seed gardens, for by puncturing the seed it permits of the entrance of fungi to the interior, with ultimate destruction of the seed.

The order Tysanoptera, or Thrips, includes a pest of tea which causes much damage in Darjeeling, viz. the common thrips of tea (*Physothrips setiventris*). This

pest causes very severe stunting of the flush, thereby reducing quantity and, by making the young leaf papery and brittle, undoubtedly affects quality also.

Amongst the Pseudo-neuroptera, termites or white ants are often troublesome, by swarming into the bush primarily in search of dead pruning snags, plucked shoots which have died back, etc., and ultimately extending their ravage to the entire frame of the bush. Of the varieties found, Odontothermes, which live in the ground, are the most widespread, but attack by varieties of Calothermes nesting in the bushes, so serious in Ceylon, is practically unknown, though it has been found to occur in tea seed gardens in the Surma Valley.

Various mites (*Arachnidea*) attack tea plants, the most important of which is Red spider (*Tetranychus bioculatus*), which occurs in all districts, particularly upon old and weak tea. The Scarlet mite (*Brevipelpus*), Pink mite (*Phyptoptus theae*) and Yellow mite (*Tarsonymus translucens*) do damage occasionally.

In the case of the more serious pests, the Tea mosquito bug, Red spider and Thrips, adequate control measures have yet to be devised. Insecticides play their part in reducing the amount of damage done, but research is pointing more and more to the fact of the condition of the plant as regards its resistance to the pest as the main controlling factor. The modification of cultural operations to increase this resistance is receiving attention.

Damage by caterpillar pests, termites, etc., has been much reduced of late years by improved methods of cultivation and pruning. In many cases modifications of cultural operations, based on an increasing knowledge of the biology of the pests, are found to be entirely adequate as a means of control.

Of the 150 fungus diseases reported found on tea about 80 are known to occur in North-East India. They

may be divided into two classes, those which are usually associated with lack of vigour in the host plant and those in which this association is not readily traceable. In the former group the commonest are Brown blight (*Colletotrichum camilliae*) and Grey blight (*Pestalozzia theae*) which attack the leaves. The alga which causes Red rust (*Cephaleuros mycoidea*) is also very commonly found on debilitated tea bushes. Violet root rot (*Sphaerostilbe repens*) frequently attacks bushes growing on waterlogged or badly aerated soil, and Die-back (*Diplodia* spp.) is often found on bushes growing in soils subject to drought.

A considerable number of species attack individual branches rendered moribund by other causes, such as unsatisfactory systems of pruning and plucking.

The diseases which it has so far not been found possible to connect with the condition of the bush include Blister blight (*Exobasidium vexans*) and Copper blight (*Loestadia theae*) on the leaves, various species of *Corticium, Nectria cinnabarina* and Thread blight on the stems, and *Fomes lamaoensis, Ustlina zonata* and *Rosellinia arcuata* on the roots.

Blister blight is the most serious of the leaf diseases in North-East India. It was known in Upper Assam in the early days, and reached Darjeeling in 1907. In 1926 it appeared in the Surma Valley. The spores of this fungus are wind distributed and it is only possible to eradicate it from well isolated gardens. The disease only attacks succulent growth and it has been found possible and practicable to protect, by spraying, tea on which the loss will cause severe damage.

Of the stem diseases the most severe is Black rot (*Corticium invisum*), but this and other species of Corticium and Thread blight are readily removed by spraying with fungicides. *Nectria cinnabarina* requires to be cut out, but fortunately this disease is comparatively rare.

The root diseases not associated with lack of vigour in the plant are generally found to originate in decaying wood such as tree stumps, fence posts and remains of wooden bridges. The only satisfactory treatment is the removal of dead bushes together with all dead wood from the soil in their vicinity.

Of recent years the value of spraying with fungicides on a large scale has been recognized. The most efficient spray fluid is considered to be lime-sulphur solution which reduces not only fungus diseases but also Red spider. It has been found that the best time to spray a garden is in March or April, and the crop increase thus obtained is dependent upon the amount of disease present on the bush.

It is common for the lime-sulphur solution to be made on the garden and to be applied by means of knapsack sprayers, often supplied from a central battery pump. Frequently as much as a third of a garden is sprayed in a year and sometimes even more.

LEAF ON WITHERING RACKS

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CHAPTER XIV

THE MANUFACTURE OF TEA IN NORTH-EAST INDIA

The layout of a tea factory—Machinery and power—Withering—Controlled withering—Rolling—Fermentation—Firing—Sorting and grading.

IN giving an account of tea manufacture in North-East India the procedure commonly followed, discovered in practice to be the best, is described. At the same time an attempt is made to denote how particular conditions in manufacture influence the character of the finished product.

In describing the appearance, infusion, taste and character of tea certain terms are used, which are discussed and collected in the form of a glossary in the next chapter. Where these terms are employed in the present chapter they are printed in italics in order that easy reference may be made from the glossary to the text.

THE LAYOUT OF A TEA FACTORY

Tea factories in Assam are lofty, single-storied buildings, with one or more withering houses situated nearby. Modern factories are constructed of iron and floored with cement. The dimensions of a factory vary according to the crop made. The average factory may be about 200 feet long, about 80 feet wide and 30 feet high.

In Darjeeling and the Dooars, factories usually have two or three stories, the upper ones being used as withering lofts. In such cases outside withering space is reduced or entirely dispensed with. Lofts are common in the Surma Valley.

The ground floor of a tea factory consists essentially of three divisions, the rolling, firing and sorting rooms. Sometimes the leaf is fermented in the rolling room, a practice which has convenience to recommend it, but often the rolled leaf is carried to a fermenting room separate from the main building. This room is generally situated on the ground floor of a withering house, if possible, an arrangement which ensures a certain degree of coolness not always obtainable in the main factory building.

The firing room is generally the middle section of the factory, often separated from the rolling room by a thick wall to prevent the latter from getting too hot. The temperature of the firing room is usually very high, often well over 100° F., and this is to be expected since it is common for the exhaust air from the dryers to be discharged into the room. Of recent years the tendency has been to ventilate and so cool the firing room.

The power unit is generally housed in a separate room adjoining the main building. Since most tea factories have been extended and added to from time to time, it will be understood that they are not always as conveniently arranged as might be wished.

Machinery and Power

The power required to turn the rollers, to work the fans and trays of the firing machines and to work the sorting machines is usually generated by a steam engine. Such an engine seldom fails and is simple to handle, which is an advantage on an isolated garden. In the last few years many oil engines have been installed and a few gas engines. Most factories have an electric plant often run by a separate oil engine.

In some Dooars and many Darjeeling gardens, water turbines are used, and in one or two cases hydro-electric

power is generated. Water turbines can only be used regularly after June, and an engine is required for the early part of the season. The irregularity of the water supply is against its general use as a source of power on a small scale, although various schemes for the harnessing of some of the bigger rivers with a view to the wholesale production of current have been discussed from time to time.

An idea of the power required to run a tea factory under conditions in North-East India is given by the following observations.

A tea roller running empty takes about 1¾ b.h.p., and 4 to 5 b.h.p. when rolling leaf without pressure. With pressure rolling, from 10 to 14 b.h.p. may be required. A large tea dryer takes 5 to 6 b.h.p. to run. On these reckonings, a factory in North-East India making 10,000 maunds of tea in the season, and equipped with 10 rollers and suitable firing machinery, generates a peak load of about 140 b.h.p. Actually in practice not more than 80 to 90 b.h.p. are required at any time.

The tea rollers most commonly in use in North-East India are Marshall's 'Metallic' and Davidson's O.C.B. These rollers take a charge of about 360 lb. withered leaf and, following out the rolling programme detailed later, are able to deal with about 900 maunds of finished tea each in a season of 1,200 working hours. Marshall's 'Rapid' roller, somewhat smaller than the others, is also in common use.

The modern drying machines used are Marshall's 6-ft. 'Empire' and Davidson's 6-ft. Endless Chain Pressure Dryer. These are both large machines, the former capable of dealing with the first firing of 6,000 maunds and the latter of 4,700 maunds of finished tea in the season under conditions in North-East India. For the second firing, Marshall's 12-ft. 'Venetian' or

Davidson's Double Tilting Tray machines are used. These are constructed to cope with the three-quarter fired leaf from the big machines. In a similar manner the 6-ft. 'Venetian' and the Single Tilting Tray are made to second fire the leaf from the small 'Empire' and small E.C.P. respectively.

All the machines mentioned are pressure dryers, in which the hot air is forced into the lower part of the machine and allowed to rise through the moving trays which convey the leaf from the top of the dryer to the discharge at the bottom.

The earlier machines were of the suction type, in which the hot air was drawn through the machine by a fan placed above the top tray. The 'Paragon' machine is of this type, and is still used in many factories, although such machines are now being converted into pressure dryers. Pressure machines dry the leaf more regularly than machines worked on the suction principle.

In the last few years it has become customary to insulate the heater of the dryer with a housing of asbestos or similar compound. This is built round the heater at a distance of about a foot so that the air before entering the heater has to pass through this space and is thereby pre-heated. The resultant saving in fuel is considerable.

Although the dryer stoves are built to take wood, this fuel is not often used. Bengal or Assam coal is generally used for firing, and in a few cases oil burners have been installed.

As the crop of a garden increases, so more machinery is placed in the factory to cope with it. Accordingly, many factories present a maze of belts, shafting, counter-shafting and machinery. By a recent Act, all belting and machinery must be guarded, a precaution which has added to the existing confusion.

WITHERING

As the leaf is plucked on the garden it is put into a large basket by the plucking woman, and carried to the factory or weighing shed at the end of the morning and again at the end of the day's work. The pluckers are paid according to the weight of leaf plucked.

When the leaf is heaped up in the basket it tends to get hot and turn red. Temperatures of 120° F. and over are common in leaf which has been tightly packed for two or three hours. In order to avoid red leaf the pluckers are instructed to pack the baskets lightly, an unpopular order because it is imagined that leaf loosely packed weighs less than the same leaf tightly packed.

After weighment the leaf is taken to the withering house or loft. In Assam the leaf house is usually of the 'chung' type. Such a house consists of a series of floors about 3 feet apart, there perhaps being as many as 10 floors in a shed. The sheds are open, and the newer ones are built of iron and often fitted with weather boards. The floors are of bamboo strips covered with hessian. Sometimes the bamboo is replaced by thick wire mesh, but this has the disadvantage of withering the leaf too rapidly in the dry part of the season. The most even wither is obtained on a solid surface, to which bamboo and hessian approximate, since this only allows of slow drying.

The 'chung' type of leaf house is expensive but, in addition to giving a good wither, the 'chung' is easy to spread evenly with leaf. In order that the leaf on all parts of the 'chung' shall wither to about the same extent, the width of the leaf house should not be more than about 50 feet, and one leaf house should not be nearer the next than about 100 feet. When houses are close together the leaf spread in the ones to the leeward withers very slowly.

The other type of withering space in common use is the rack of wire netting. Racks are built in series, each rack being about 6 inches from the next, and each series reaching to a height of about 6 feet. A rack house may consist of three stories, open to the weather like the 'chung' house. The width of each rack is 3 to 4 feet, and as it is inevitable that the wire should sag after a time, the leaf tends to collect where the netting droops and an uneven wither results.

For even withering the leaf must be spread thinly. With a wire rack about 9 square feet of space are allowed per lb. of leaf, but with a 'chung' a somewhat greater area is usually allowed. The thickness of spreading in practice is naturally controlled by the quantity of leaf brought in and the withering space available, and on heavy cropping days the spreading may be by no means ideal. It is, however, uneconomical to provide enough withering space to cope with the very heaviest days.

In Assam on the average day in the full season about 1 per cent of the total crop is made, and it is reasonable to provide sufficient withering space to deal with this amount of leaf. On this reckoning, a garden making 10,000 maunds of tea in the season will produce on the average big day about 100 maunds of tea, resulting from about 400 maunds or 32,000 lb. of leaf. Spreading at 1 lb. leaf to 9 square feet, this amount of leaf will require 288,000 square feet of withering space. Many gardens have much more space than this which is not necessarily used for thinner spreading, but for keeping the leaf over in case it is not ready. When extra space is not available, the 'chungs' or racks must be cleared when fresh leaf is brought in and the leaf taken from the racks must be manufactured whether it is withered or not.

In the Dooars and Surma Valley, where much of the tea is left unpruned and the season thereby lengthened,

the average big day produces about three-quarters per cent of the total crop. Accordingly, less withering space is required than in Assam where unpruned tea is at present uncommon.

To make the best possible tea from the leaf available the leaf must be withered evenly and at a low temperature. In the rains in North-East India weather conditions are such that 100 lb. leaf can be dried to about 65 lb. in about 18 hours. This is considered to be an ideal wither under rains conditions. In the spring when the atmosphere is dry a good wither can be obtained in 12 hours or less. In Darjeeling under controlled conditions, a suitable wither is obtained sometimes in 8 hours.

During a wet spell in the rains it is often impossible to wither more fully than about 80 per cent (100 lb. leaf dried to 80 lb.). Such leaf is smashed up on rolling and gives a *flaky* tea.

To fire under-withered leaf the firing temperature is often raised in order to enable the drying machine to cope with the leaf as it is brought in from the fermenting room to be fired. High firing temperatures on very wet leaf produce a tea which is *brownish* in appearance. This can be avoided by firing slowly at normal temperatures.

As explained in an earlier chapter, no important apparent chemical change takes place during withering, and if any such does occur, the wither is a bad one. Accordingly, there can be no chemical test for the state of the wither. The test applied by the planter for checking the degree of the wither is the same as that used by the Chinese for many centuries. The stalk of the shoot is bent, and if it is flaccid enough to do so without breaking the wither is considered to have proceeded far enough. Experience soon teaches a man to judge an ideal wither, but in learning this a check may be obtained by weighing a known quantity of leaf when

it is first spread and again at intervals. As mentioned above, when such leaf has lost 35 per cent of its original weight it is sufficiently withered under rains conditions in North-East India.

When under-withered leaf is rolled and spread on the fermenting floor the colour is usually bright red. A similar colour can be obtained by spraying any fermenting leaf with water, and a bright colour on the floor is no guarantee that the infused leaf will be bright. Indeed, the infused leaf of tea made from under-withered leaf is generally *greenish*. The infusions from such leaf are usually *raw* and *rasping*.

If the shoot is withered too rapidly the thin leaves may over-wither and blacken, whilst the bud and stalk may remain under-withered. Such leaf when manufactured gives *uneven* infused leaf, containing dark coloured pieces which represent those parts of the shoot blackened in withering. Over-withered leaf will not ferment well, owing to its dryness, and hence tends to produce *thin* liquors. The practice of adding water to the leaf in the roller if the former is over-withered is a good one, because it aids fermentation and improves the colour of the infused leaf.

Racks often produce unevenly withered leaf because parts of the shoot are liable to hang through the mesh. In this manner *silver tip* is often produced. The *tip* in tea should be yellow in colour on account of the dried tea juices which are smeared on the leaf hairs during rolling. If the tip is over-dried in withering, then the hairs will not 'take' the juice, and thus appear white or grey in colour.

The most suitable degree of wither varies with the temperature. As already mentioned, a 65 per cent wither is suitable under normal rains conditions in Assam. In a hot spell the temperature may rise to 100° F., and

then a 65 per cent wither reddens the leaf, and the tea made gives *thin* liquors and *dull* infusions. In the spring and autumn, when temperatures are low, a fuller degree of wither than 65 per cent is desirable.

The influence of the degree of the wither on the tea produced may be summarized as follows. Under-withered leaf gives a *flaky* tea, *raw* liquors and *greenish* infused leaf. Over-withered or unevenly withered leaf gives tea with a *thin* liquor and *uneven* infused leaf. Correctly withered leaf, if subsequently treated properly, makes for *black, well-twisted* leaf, *strong, pungent* or *brisk* liquors and *bright* infused leaf.

Controlled Withering in North-East India

The question of the economic value of controlled withering lofts in North-East India is still a debatable one. In Ceylon much study and experiment has been given to the subject, and lofts are so constructed that complete control over the air and its movement is obtained. North-East India is far behind Ceylon in the matter of loft control.

There is at present some doubt as to the necessity of complete control in lofts in all parts of Ceylon. Climatic conditions in Ceylon vary as widely as those in North-East India. The low-grown tea areas have conditions similar to those in Assam during the rains, whilst high-grown conditions resemble those of Darjeeling. It follows that what may be economically sound in a district when natural withering conditions are always difficult may not be so in a district where a good natural wither can usually be obtained. On this account it is proposed to discuss controlled lofts under conditions in North-East India.

A study of the rate of transpiration of the leaves of plants has shown that the most important factor

controlling this phenomenon is temperature, followed by absolute humidity and then by wind velocity. The percentage influence of these factors has been worked out and it has been found that the influence of temperature is 55 per cent of the whole, that of humidity 19 per cent and of wind velocity 9 per cent.

Although the withering of leaf is a different process from the transpiration of water from a live, growing leaf, it may be anticipated that the factors influencing the removal of water in both cases will be similar. In fact, from observations made in withering lofts, it appears that the withering of tea leaf to the degree usual in tea manufacture is influenced mainly by temperature, to a much smaller extent by humidity and only to a minor degree by wind velocity.

Where the temperature rises well above 80° F. for a few hours each day as it does in Assam, the need for a loft is small. In the Dooars, where during a wet spell the air is saturated and the temperature may remain at about 80° F. for several days, a loft is essential if the leaf is to be withered in a reasonable time. In Darjeeling, low temperatures make natural withering a practical impossibility.

The development of controlled withering lofts has been along obvious lines. In the Dooars and Darjeeling districts, first of all the hot air from the firing room was allowed to pass through holes in the ceiling and to find its way through the loft. Exhaust fans at the ends of the loft followed.

The drawback to this system is obvious, for the exhaust air of the dryers is usually at 120° F. and this, mixed with the air of the firing room, produces an atmosphere in the loft with a temperature of about 100° F. If strong fans are installed in the loft this temperature may be lowered somewhat, but such a loft

invariably produces red leaf, and where the hot air enters the leaf is usually blackened and over-withered.

The next stage in control was the introduction of the central bulking chamber in which hot air from the firing room is bulked with outside cool air. At first the bulked air was drawn through the loft by suction. It was then found that better bulking was obtained by placing a boosting fan in the bulking chamber and moving the bulked air through the loft under pressure.

As experience accumulated it was found that in a loft much longer than 60 feet the boosting fan required the assistance of a suction fan at the end of the loft, in order to move the air over the leaf at a sufficient speed. Lofts are seldom longer than 100 feet. The bulking chamber is situated over the firing room and reaches from the ceiling of the latter to the roof of the factory.

The lofts are situated one on either side of the bulking chamber and there may be three stories of lofts, making a total of six in a factory. The bulking chamber may be about 20 feet in width, making the total length of the upper stories of the factory about 220 feet in extreme cases.

A common width for a loft is 40 feet and in such cases the loft windows may be opened on a fine day and a natural wither obtained. In some lofts no such contingency is allowed for and the loft may accordingly be 70 feet or so wide.

In controlled lofts the temperature should be kept well below 90° F. if possible, and the difference between the wet and dry bulb thermometers shown by the air on leaving the bulking chamber should be about 4° to 6° F.

Under certain conditions it is observed that the leaf near the bulking chamber withers more fully than that at the exhaust end of the loft because the air has a much greater drying capacity on entering than on leaving the

loft. To obviate the uneven wither thus obtained, systems were introduced whereby the direction of the air current in the loft could be reversed and the wither evened up throughout the loft. With this object, two systems of loft control, known as the reversible and the alternating, have been developed and patented.

In the reversible system the air first enters loft A from the bulking chamber and passes over the leaf to the end of the loft where it enters a small bulking chamber, thence to loft B which is above or below loft A. The passage of the air through the second loft is assisted by a fan placed in the end bulking chamber. After it has traversed loft B, the air is exhausted by side windows near the centre bulking chamber. The drying is greatest in loft A where the air enters, and least in loft B where the spent air is discharged. After a suitable period has elapsed, by closing certain doors and windows and opening others, the air is first sent into loft B and then back through A.

In the alternating loft the air is sent either directly through the loft and out at the exhaust end, or first through a false loft, between the ceiling of the top loft and the roof of the factory, and then through the loft in the reverse direction, i.e. from end to centre, and out through side windows.

The value of these systems has perhaps been overrated. When air is sent through a loft the principal change, provided the air speed is reasonably fast, is a fall in temperature. A few calculations will show that the absolute humidity of the air will change very little. The increase in the relative humidity will depend on the fall in temperature. In practice in Ceylon it is found that it is only necessary to reverse the air current for a fraction of the time that the direct current is used. Observations in India have shown that on warm days when the loft

temperature is practically the same as that outside, a reversion of the current is wholly unnecessary.

The doubt regarding the value of fully controlled lofts under all conditions in Ceylon has already been indicated. In North-East India no less than five modern controlled lofts have been erected and have been in use for several seasons. Their commercial value is not yet proven, and judging by results the erection of more lofts does not appear to be justified. This is surprising, since controlled lofts ensure an even wither at moderate temperatures. Must we then relinquish our cherished belief that a good wither is essential for the making of good tea, or are the limit conditions of the leaf which constitute a good wither so wide that the wither obtained under natural conditions falls within them? In any case the erection of controlled lofts in North-East India should still be regarded as experimental.

Although the value of complete control in Assam may be open to doubt, in the Dooars and Darjeeling some assistance is essential. The lofts already in existence there can be improved by lowering temperatures, by a better regulation of the air movement, and by making the loft more or less air tight.

In many of the lofts centre bulking chambers have been built, but these rarely do the work efficiently and are used chiefly as a means of shutting the hot air off from one loft or another. By a simple arrangement of fans, windows and ducts the air can be bulked to give a mixture of suitable temperature and humidity, although in practice this is seldom done.

Rolling

It is usual to start rolling the leaf as early as possible in the morning, and during the heavy flushing period rolling must be begun whether the leaf is withered or

not, in order to clear the racks for the incoming leaf. During the second flush when the atmosphere is still dry at night, the leaf is frequently ready for rolling at midnight or soon after.

When it is decided to start rolling the leaf is swept up from the 'chungs', or shaken from the racks, and carried in baskets to the rolling room. In the case of loft withering, the leaf is shaken from the racks and put down a chute leading to the rolling room.

Fermentation starts in the roller, and on this account every attempt is made to keep the rolling room cool, for at high temperatures it is difficult to control fermentation. In rolling, especially in the first roll when the fine leaf is present, the leaf heats up and temperatures of 90° F. and higher are common. This heat is due to fermentation rather than friction, for the coarse leaf, although rolled with pressure, does not heat up nearly as much as the fine leaf, because its rate of fermentation is much slower.

It is common to roll three times, in half-hour periods. The first period is without pressure, and at the end of this time the leaf is dropped from the roller, by means of a trap door in the table, into a trolley. It is then taken to a green leaf sifter, either of the rotary or reciprocating type. The sieve is a coarse one, with a 3 to 6-mesh.

During rolling the leaf forms into balls. Sifting not only cools the leaf but also breaks these balls, thus ensuring even fermentation. The aeration given in sifting induces vigorous oxidization of the leaf.

The leaf which comes through the sieve consists of the tenderer, finer parts of the shoot, which are sufficiently damaged by one rolling. This fine leaf is taken straight to the fermenting room. It contains most of the 'tip' of the tea, and this valuable part of the shoot is liable to be spoilt if rolled too hard. Hard rolling

plasters down the fine hairs with juice and thus robs the 'tip' of its appearance. The fine leaf constitutes about 30 per cent of the bulk of shoots of two leaves and a bud.

The spill from the green sift is put back into the roller and rolled hard with pressure. During pressure rolling the cap of the roller is raised at intervals to prevent over heating and to aerate the leaf.

During pressure rolling juice is expressed from the leaf either as froth if the wither be a full one, or as a watery liquor if the wither be light. The froth is often allowed to drop through the roller into the trolley beneath, where it is eventually re-absorbed by the leaf when the latter is discharged. The watery juice is generally allowed to run away, for it is considered uneconomic to waste heat drying this for the sake of the solid matter it contains.

Some years ago a machine called the Perman Expressor was used for expressing juice from under-withered rolled leaf, thereby saving fuel in firing and giving, it was claimed, a brisker tea. Such expressed leaf was certainly easy to fire and, where machinery was short, may have obviated stewing and in this way may have produced a brisker tea. Experience, however, showed that any improvement in the tea was not worth the labour spent in working the machine and nowadays the Expressor, like many other tea inventions, can be seen derelict. In one case a hydro-extractor, such is used for drying cotton in mills, was used with an object similar to that of the Expressor, and with a similar result.

After the second roll the leaf is again green sifted. Sometimes this is done only to cool and aerate, but it is sometimes used as a means of removing more fine leaf.

The leaf is now rolled for the third time, again with pressure. At the end of this period the leaf is sifted and

then taken to the fermenting room. The total rolling period, including rolling and sifting, is about two hours.

There are many variations to the above system. When there is much leaf to be dealt with the rolling period may be cut down. In some cases a roll is given at the end of fermentation, just before firing. This is done with the object, it is said, of putting a final twist on the leaf and of brightening the colour. Actually this roll expresses a little more juice and makes for fuller fermentation.

In North-East India the rollers revolve at about 60 to 70 r.p.m. compared with 45 r.p.m. in Ceylon. Slow rolling has been tried in Assam but not with success. This failure may be due to several causes, one of which may be the high temperatures which make it essential that the rolling should be finished as quickly as possible so that the leaf can be placed in the cool fermenting room. Another reason may be that the lightly withered leaf in Assam needs the vigorous action of rapid rolling to break and damage it sufficiently, whereas the more flaccid leaf given by a full wither can be sufficiently damaged by slow rolling. Slow rolling gives a tea of better appearance than fast rolling.

The pressure exerted in rolling largely decides the amount of damage done to the leaf and in this way not only influences the amount of fermentation but also the appearance of the finished tea. Hard rolling makes for full fermentation, and for *strong, thick* liquors which *cream down,* provided the leaf is fine. Generally speaking, the lighter the wither the harder must be the rolling to produce these qualities. Too hard rolling rubs off the outside skin from parts of the shoot and exposes what is known as *stalk,* especially in coarse leaf.

The development of high temperatures in rolling makes for *thin* liquors with *dull* infused leaf. In fact

high temperatures during withering, rolling or fermentation tend to produce these qualities.

It has long been known that, within limits, the more the leaf is damaged in rolling the stronger are the liquors of the teas made. As an aid to hard rolling, rolling tables are often fitted with ribbed battens. Generally speaking, however, the capacity of the ordinary roller to damage the leaf has been pushed to its limit. Accordingly, other means of damaging the leaf have been tried.

In many factories the leaf is cut by a chaff-cutting machine before it is rolled, and by this means a kind of mash is obtained in rolling, and the leaf is very fully fermented. Tobacco cutters are also in use, and the partially rolled leaf is by this means cut into very fine strips and a full fermentation obtained. The tobacco cutter produces a high percentage of fannings and cannot therefore be put into general use.

Various attempts have been made to produce a machine which will damage the leaf more than is possible in rolling, and at the same time avoid undue heating and loss of juice. The tea produced by such a machine must not differ greatly in appearance from that demanded by custom.

After much experiment the McKercher C.T.C. machine (crushing, tearing and curling) was evolved. Briefly, it consists of two metal ribbed rollers which work like a mangle. One roller makes about 700 r.p.m. and the other about 80 r.p.m. Partially rolled leaf is fed into the machine, and as it passes between the rollers is not only crushed, but distorted. The leaf is only under pressure for the fraction of a second and has no time to heat up, whilst any expressed juice is re-absorbed by the leaf immediately it passes through the rollers.

At first, the tea produced on the garden where the machine was invented sold well, and on the strength of

this success many machines were installed in India and Ceylon. With the resultant glut the demand for these teas fell off and after a year the machine was largely abandoned. The tea tasters complained that C.T.C. teas were over-fermented and lacked flavour.

The precise chemical difference between C.T.C. teas and those made by ordinary rolling has not been determined, but it seems probable that the very full degree of oxidization of the tannin which the C.T.C. machine makes possible is undesirable, especially in fine teas. It is possible, however, that the C.T.C. may find a use on medium leaf in non-quality periods if the leaf is well withered and if the C.T.C. process is introduced towards the end of fermentation, after the tea aroma has had time to develop. A full wither makes the precipitation of the most undesirable tannin products by leaf proteins possible.

Fermentation

The rolled leaf is taken to the fermenting room and spread on the floor, which is usually of cement and sometimes of glass or glazed tiles. Sometimes cement or glass racks are used for the fermenting leaf.

The leaf is spread about two inches thick, and during fermentation the temperature shown by a thermometer placed in the leaf rises from about 80°, assuming this to be the air temperature of the room, to about 86° F. After a period of about 1½ to 2 hours the temperature falls off again to that of the room. The total fermentation period, including rolling, is about 3½ hours.

Experience shows that the complex reactions which constitute tea fermentation march in best order at a temperature between 75° and 80° F., and attempts are made to keep the temperature down as near the latter as possible. This is accomplished by humidifying the air. Humidification may be carried out either by the

simple methods of spraying water into the room or by hanging up wet sacking, or by the installation of humidifiers such as are commonly used in cotton mills. By means of the latter the room temperature can be reduced to about 80° F. and a relative humidity of 95 per cent can be obtained on most days. A high humidity is of value in that it prevents the leaf from drying as it lies on the floor. It will be understood that the process of fermentation is largely inhibited if the surface of the leaf is dry.

'Mist chambers', introduced from Ceylon, are also used as a means of cooling the fermenting room. A mist chamber consists of a small room fitted with numerous nozzles or atomizers which produce a cloud of fine spray. This spray is blown into the fermenting room, after having passed certain baffles which retain the heavier drops of water. Although the mist chamber answers well in a small fermenting room, the large rooms used in North-East India are frequently beyond the capacity of the average mist chamber installed. The use of humidifiers seems to be a more logical procedure, for by this means humidity is produced just where it is wanted.

The question of the action of micro-organisms in fermentation has received much practical attention in North-East India. It was at one time thought that yeasts might be responsible for producing certain flavours, and round about 1923 these organisms were collected from leaf in areas noted for flavour, like Darjeeling, cultured, and taken to other districts where they were added to the local leaf when it was being rolled. Although high hopes of introducing flavour into areas which produced poor teas were raised, nothing came of the experiments. A similar failure had been recorded in Java many years before.

The action of bacteria on the fermenting leaf has been studied. Growing leaf carries a considerable bacterial flora, as does the ordinary fermenting room floor. Although the bacteria found normally in tea factories have no action on fermenting leaf, and although the action of micro-organisms as an important factor in tea fermentation had been examined many years before and discarded as unimportant, it was considered advisable in North-East India in the year 1931 to render the fermenting room floor sterile. To do this, electrolitic chlorine was used for washing down the floors and also for cleaning rollers and trolleys. What action resulted beyond the destruction of the bacteria was not worked out, but complaints by tea tasters of tainted teas from treated floors led to the hasty abandonment of the use of the disinfectant. In the meantime many cement floors, which with long use had become porous and impregnated with bacteria which electrolitic chlorine failed to dislodge, were, on the strength of a hypothesis discarded many years before, replaced by new floors. After much expenditure and, in some cases, marked loss in sale prices, the old process of washing down the floor with water as often as possible was reverted to. Occasional steaming or washing with weak permanganate solution is customary, especially if any strange smell is detected on the floor.

The effect of over- and under-fermentation on the quality of tea are both well known. Leaf fermented for too short a period (e.g. 2½ hours including rolling) gives tea with liquors *raw* or bitter to taste and *weak, light, thin* or *washy* in body. The infused leaf is *greenish*. Assuming the fresh leaf to contain 22 per cent tannin, such tea may contain 15 per cent.

As fermentation proceeds, *rawness* gives place to *briskness* or *pungency*. The liquors become redder or

thicker, and *strength* develops. Strength is apparently a combination of pungency and thickness. Such tea gives *bright*, red coloured infused leaf, and on cooling a precipitate, known as the *cream*, forms. At this stage (about 3½ hours' total fermentation) the tea contains about 12 per cent tannin.

Further fermentation produces a *flat* or *dead* tea, with no *pungency*, and gives liquors which are *dull* or brownish in colour. On cooling, a *murky* or *muddy* precipitate forms, and the infused leaf, instead of being the bright colour of a new penny, is the dull colour of an old penny. Although this tea contains only slightly less tannin than the strong tea fermented 3½ hours, certain important chemical changes in the tannin have taken place, the exact nature of which is unknown at present.

In times when flavour is marked it is found that a shorter fermentation period than usual is necessary in order to make the most of this valuable property. Thus some of the liquoring qualities of the tea are sacrificed, but the flavour more than compensates for the loss. The fact that special seasonal flavours develop more quickly than the ordinary tea aroma associated with all black teas has already been mentioned. Indeed, it is considered by some observers that the substances responsible for special flavour are present in fresh leaf and do not require the process of fermentation for their development. Since these substances are very volatile it is further considered that a long wither or ferment, especially at high temperatures, reduce flavour.

Firing

In North-East India tea is fired in two operations. In the first it is dried just to crispness, a stage known colloquially as 'twelve annas' or three-quarters dry.

(It is common in India to express fractions as parts of a rupee which contains 16 annas.)

Fairly definite information is available on the subject of firing, but the process is still a difficult one to carry out. The state of the leaf as it is brought to the machine frequently changes as does also the rate at which it is brought, and, accordingly, continuous changes in the speed of the dryer trays, the thickness of the spreading and the temperature of the air blast are necessary if the best is to be made of the leaf.

Thin—slow—low, are the maxims for firing tea. The leaf must be spread thinly on the trays, as thin as the automatic spreader allows. The leaf should pass through the machine slowly, in not less than 20 minutes for the first fire, preferably 25. The temperature of the air as it enters the dryer should be low, about 190° F.

In addition, it is essential to drop the tea from the first fire at least three-quarters dry, and the air temperature below the top tray should be 140° F. Unless these two conditions are observed, the fermentation process will not be stopped readily enough. As a result the tea will lose *pungency* and give *soft*, *dull* liquors. The tea may also be pronounced *stewed* or *sweaty*, which terms indicate a shortage of tea characteristics, probably the tea essential oil.

A temperature of 140° below the top tray indicates that the leaf on entering the machine is submitted to this temperature. After the air has passed through the leaf and heated up the latter, it leaves the dryer at a temperature of about 120° F.

Unless the leaf is dried slowly in the first fire it is liable to be case-hardened, as a result of which the outside of the leaf is much more dried than the inside. During the second fire, the moisture thus imprisoned within the leaf may, on escaping, raise a *blister* on the

leaf. An additional fault which comes from too rapid firing is the formation of a layer of microscopic bubbles on the surface of the leaf. On sorting these minute blisters are broken and present a *grey* surface. Although most teas from North-East India show a certain amount of greyness, this characteristic can, in extreme cases, lower the value of the commodity.

The second fire is very important in that here the leaf is submitted to heat whilst it is dry, and on this account gets its keeping qualities. A full '16-anna' fire is necessary in the second firing, otherwise the tea is likely to *go off* on storing.

Tea should not be kept in the firing machine after it is fully fired, but must be discharged as soon as it is dry, otherwise it may be *high-fired* or *burnt* if the firing temperature is above 200° F. At lower temperatures such treatment may produce a tea which is termed *dry*. Tea which is fed into an empty or incompletely filled dryer is liable to be fully fired when it is about half way through the machine, and will pass along the last two or three trays in a dry condition, with the results indicated. By the time a tea reaches Home a touch of the fire may disappear, but *dryness* persists.

Tea is sometimes described as *bakey*, an expression denoting a degree of high firing. The term *malty* probably has a similar significance and may result from the same cause, although *maltiness* is a desirable characteristic. The caramellization of the sugars in the leaf may account for the malty taste.

In order that tea shall keep well it must be dried slowly and thoroughly. This necessity is fully recognized by the Chinese who take many hours to basket-fire their finest teas. Tea carefully fired in a machine will keep well enough, but during rush periods of the season it is difficult to fire with care. In such cases, rather than

risk under-firing it is preferable to raise the initial firing temperature of the machine to 200° F. or more, and any quality lost by so doing will be compensated for by the production of a tea which will keep well.

Sorting, Packing and Classification

As tea comes from the dryer it is a mixture of long and fine leaf, which has to be sorted or graded. In factories which sell tea partly on appearance the grading is done with great care. The tea is first put through a series of long rotary sieves which make about 25 revolutions per minute. The first sieve is usually of 13 or 14-mesh and the tea which falls is composed of the fine broken leaf and 'tip'. This mixture goes by the name of Broken Orange Pekoe.

The spill from the first sieve passes to a second one of 11 or 12-mesh. The leaf which falls is longer than that from the first sifting and is largely composed of the first leaves of the shoot. This mixture is called Orange Pekoe.

The spill is then put through a breaking or cutting machine and again sifted, this time probably through a mechanical sorter of the reciprocating type. Thus coarser grades, known as Pekoe, Pekoe Souchong and Broken Pekoe Souchong are made. These grades result from the second and third leaves and the stalk of the shoot. During sorting, the brittle leaf is much broken, and the flakes formed in this manner are separated from the grades by sifting or winnowing, and are known as Fannings. The powder which accumulates is known as Dust.

There are naturally many variations in sorting and the same grades vary somewhat from garden to garden. During sorting, stalk is carefully picked out, either by hand or by stalk extracting machines.

On many gardens, the teas of which are bought regularly by blenders, the same care in sorting is not taken, and all the tea is cut before sorting begins. Of recent years the tendency has been towards the making of cut or broken grades as opposed to leaf or natural grades.

The cutting or breaking machines in use in North-East India are the Savage and Reid. The mechanical sorters in use, and by this is meant the sorter of the reciprocating type as opposed to the rotary sifter made on the garden, are the Moore, the Magic and the Chalmers.

The grading is never quite perfect and there is always the temptation to sift the coarser grades again to take out any of the finer leaf which may have got through. Too much sorting and cutting produces *greyness* in tea, and may partially destroy the 'tip'. If tea is cut too much in order to produce a broken grade it may be called *choppy*. A broken tea should be broken in rolling and not in a cutting machine.

The grading of tea assumes some importance when the liquors are poor. Then the grade must be true to type, *even* and *clean*. This last indicates freedom from dust and fibre. A small percentage of dust is sometimes left in a grade in order to strengthen the liquors, and although this object is achieved something is lost in the valuation owing to the presence of the finer particles.

Tea is very hygroscopic and readily takes up moisture. When it comes from the dryer it contains from 1 per cent to 3 per cent moisture, and by the time sorting is finished it may contain as much as 8 per cent. An undue increase in the moisture content can be avoided by sorting in a reasonably dry atmosphere, and experiment has shown that if in the sorting room the difference between the wet and dry bulb thermometers is 9° F.

then the tea will absorb enough moisture to bring the content up to 6 per cent, at which figure it should be packed. In practice no attention is paid to the humidity of the atmosphere of the sorting room.

If tea is packed with a moisture content of more than 6 per cent it may *go off* on keeping. This is probably due to the presence of moulds in the tea which grow if sufficient moisture is present. Apart from this undesirable change, other slight changes take place, known as post-fermentation, by virtue of which a *mellowness* or *maturity* is developed. These characteristics are not present in freshly made tea, nor do they appear in tea which is packed too dry.

Tea is generally sorted the day after it is made and is then stored in large bins which are erected in a dry part of the factory. When enough tea has accumulated to make a break or invoice the bins are emptied and the tea bulked, generally on a wooden floor to avoid dampness. The bulking is done with shovels in a simple but effective manner.

After bulking, the tea is then final fired, a process spoken of as *gap*-ing or *pukka-bhatti*-ing. The tea is passed through a firing machine, thickly spread, in about 10 minutes at a temperature between 140° and 160° F. In this manner the moisture content of the tea is reduced by about 2 per cent.

The tea is packed warm. The chests are generally three-ply wood, lead or aluminium lined. Each chest holds about 118 lb. of tea, less with the leaf grades and more with the finer grades. Until recently the use of country made boxes was common, but this practice has fallen into disuse. Three-ply wood is made at Margherita in Assam but imported boxes supply most of the demand.

At this stage it is convenient to tabulate the moisture

changes in the leaf during manufacture. The figures given below are approximate.

	Percentage of Moisture
Fresh leaf	77
Withered leaf	65
Fermented leaf	65
Three-quarter fired tea ..	26
Fired tea	1 to 3
Packed tea	6

The moisture content of tea in a properly packed box does not show any appreciable change between India and England.

The importance of packing tea with the right moisture content is so great that on many gardens apparatus is installed for determining the moisture. For this purpose the tea is usually dried in a small steam oven, the temperature in which is a little below 100° C. When moisture estimations are made in London the samples are sometimes dried in a hot air oven at a temperature of about 105° C. The moisture content given by this latter process is higher than that given by the former, and on this account the wrong assumption is often made that tea picks up moisture in transit.

A few remarks may be made about the classification of India teas. All gardens can produce all grades or sortations of tea, but the grade is no indication of the absolute value of the tea, although the finer grades of a garden almost invariably bring a better price than the coarser grades of the same garden. India teas, and the same holds with those of Ceylon and Java, are classified by the grade and by the garden name. Some indication regarding the season at which the tea is made, such as second flush, rains or autumnal, is also necessary. The fullest classification would also include the district name in which the garden is situated, but to the trade this last is superfluous.

CHAPTER XV

TERMS USED IN DESCRIBING TEAS

Tea tasting—The influence of leaf on quality—A glossary of tea tasters' terms—Terms describing the appearance of the tea—The infused leaf—The liquors—General characteristics.

THE general nature of the subject of the present chapter would appear to demand its inclusion at the end of the descriptions of the tea countries of the world. It is placed after the account of tea and tea manufacture in North-East India, however, because the information contained herein was gathered mostly in Calcutta. Some of the expressions used in describing teas have a local significance, and a term used in a certain sense to describe an India tea by a Calcutta taster may be used in a different sense in describing a Ceylon tea for instance, or even the same India tea, by a London taster. Accordingly this chapter should be regarded as an account of tea tasting terms used in Calcutta to describe India teas.

In assessing the value of a tea, account is taken of the appearance of the dry leaf, the colour and aroma of the infused leaf and the taste and flavour of the infusion. The properties of the infusion or liquor are the most important in the majority of teas, but it is seldom that a good tea shows bad infused leaf.

Only the more obvious differences in tea infusions can be readily detected by the layman, and the question is often asked, If the buying public cannot detect minor differences between teas, why trouble about such differences on the tea market? The answer is that eventually the buying public does detect minor differences, and if the quality of a certain blend is allowed to fall off, the change is reflected in reduced sales within a few months.

Tea Tasting

The tea taster's infusion is made from a quantity of tea equal in weight to a sixpenny-piece or a silver 4-anna piece (about one-tenth of an ounce, 3 gm. or 34 grains). The tea is placed in a mug of capacity about a quarter-pint, fitted with a lid. Boiling water is poured on the tea and the infusion allowed to stand for 6 minutes, after which the tea is decanted off into a handleless cup of a capacity the same as the mug. The infused leaf is shaken from the mug on to the lid and thus exposed for inspection.

After an interval of a few minutes, when the infusion and infused leaf have cooled off somewhat, the latter is examined for colour and the former tasted. In tasting, the taster sips a little of the liquor either from the cup or from a spoon, usually with a loud sucking noise said to result from the attempt to distribute the liquor all over the palate. After tasting, the liquor is spat into a receptical for the purpose. Some time later, when the tea has cooled considerably, the liquor may be examined for 'cream', the precipitate which settles from a strong tea, although the taster can usually tell from the look of the hot infusion whether it will 'cream down' or not.

Tea is generally tasted without milk, but blenders add milk to see how the tea 'takes' it. A good tea with milk shows an amber colour as opposed to the greyish colour given by poor tea. A blender's cup is about twice as large as the ordinary tasting cup and twice the amount of tea is infused.

In America, tea tasters usually infuse the leaf in the cup and taste the liquor in the presence of the infused leaf. The latter is examined by removing with a spoon. Green teas are similarly infused and tasted.

For many years chemists have tried to find some relationship between the analysis of a tea infusion and the quality and value of a tea as denoted by the taster. No appreciable correlation has been obtained, first because the minor differences detected by the taster's palate are too subtle for analysis, and secondly because the methods of chemical analysis are not sufficiently discriminating to distinguish between even the more obvious properties of an infusion.

The following illustrates one important direction in which an analysis is inadequate. All the tannin bodies in a tea infusion are estimated as a group and returned as 'tannin'. It is known that tea tannin is present in an infusion in several modifications which are responsible wholly for *rawness*, *briskness*, *pungency* and in part for *strength*, *colour* and *thickness*. The 'cream' is composed mainly of tannin bodies. It will hence be understood that an estimation which combines the substances wholly or partly responsible for all these qualities, and gives no indication as to their respective proportions, cannot be closely correlated with the properties of the liquor.

Most of the taster's terms refer to shortcomings or bad characteristics in teas. Many of these faults, as indicated in the previous chapter, may be developed at any stage in manufacture. Thus, *dull* infused leaf may be due to poor leaf, over-withering, over-fermentation or incorrect firing. It is therefore not an easy matter for a tea maker to trace a fault to its source, and still harder to rectify it since many faults result, indirectly, from a shortage of labour, factory space or machinery.

The Influence of Leaf on Quality

In the last chapter the influence of various conditions in manufacture on the quality of the tea produced in North-East India was described. The influence of the

leaf on the quality of the tea made in this area may now be briefly considered.

The liquoring qualities of a tea, which depend on the tannin and tannin products in the infusion, are governed largely by the fineness of the leaf. Fine leaf will give teas which have liquors described as *thick*, *strong* and *brisk* or *pungent*. Coarse leaf gives *thin*, *washy* and *weak* liquoring teas with a *plain* or *coarse* character. Careful manufacture reduces the degree of these undesirable qualities.

Quality tea can only be made from fine leaf. The exact significance of the term *quality* is difficult to fix, and some tasters consider that it is only present in teas from certain districts and never in teas from other districts, however fine may be the plucking.

True *pungency* is also considered by some tasters to be confined to teas from certain districts and also to certain periods.

The infused leaf of second flush teas is often *copper* coloured, due to the fact that at this time of the year the tannin content of the leaf is high. At all times the brightness of the infused leaf is governed primarily by the tannin content of the leaf when it is plucked.

Flavour and *aroma* are closely allied, evanescent qualities which are apparent at certain times of the year and are marked in North-East India in the second flush and in autumnal teas. How to produce flavour is not known. According to some observers it is lost by a long wither and by high temperatures during manufacture. On the other hand some experienced planters assert that when flavour is present no special precautions are necessary to conserve it.

In the early part of the season in North-East India the leaf is often stunted, possibly by an attack of Green fly, and such leaf gives tea with a characteristic flavour.

A tea with a touch of flavour is described as having a good *nose*. A *hay* flavour is one which often precedes the autumnal. A *weedy* flavour is reminiscent of dried grass, and is undesirable.

Second flush flavour is greatly influenced by growing conditions. For marked flavour the bushes must be in such condition that the 'tippings' should practically be finished and the plucking surface of the bush completely made before the second flush appears. Further, conditions should be such that the third flush leaf has not come through in sufficient quantity to make its weight felt in the second, for third flush leaf has no marked flavour. The best second flush tea is made when growing conditions ensure that the leaf consists predominantly of the second flush.

The 'tippings' from unpruned bushes make teas with good liquors and often with some flavour.

In the rains, fine leaf and careful manufacture give teas highly valued for colour, strength and thickness. Real pungency or marked flavour are usually absent at this time.

A Glossary of Tea-Tasters' Terms

Good tea gives a liquor which is thick and bright red in colour. On cooling it gives a deposit known as the 'cream'. The liquor tastes pungent and strong, and has flavour.

In the glossary below the terms employed by tea tasters in describing India teas are given. The list does not pretend to completeness, and only terms which are used in their ordinary sense are given, for there are a good number of terms used by individual tasters which convey little to the average tea planter. Thus, in one case, a tea infusion was described as tasting like a 'bandsman's tunic'. Such an expression connotes unpleasantness and may denote sweatiness, but gives no guidance

to a planter who wants to trace a shortcoming in his tea to some incorrect factory procedure.

A great difficulty in forming a glossary arises from the fact that certain terms are used to mean one thing in Calcutta and another in London. Other expressions may have totally different meanings applied to them by different tasters. For example, the term *some ends* was used originally to denote some ends of 'tips' in fannings. Confined to this grade, the term did not lead to confusion. Later on it was applied to other grades and then it was used by some tasters to denote the presence of stalk.

Used in either sense the term is undesirable because stalk and 'tip' are already available. Obviously the term, if used at all, must be defined. In such a case as this the person constructing the glossary must be given the latitude assumed by the earlier lexicographers, and judge the case on its merits. As an abbreviation of *some ends of tip* the expression *some ends* may be claimed to refer to 'tip', but since the present generation of tasters is not consciously using an abbreviation, it is only logical that *some ends* should refer to stalk, since the stalk is the end of the shoot and the 'tip' the beginning. Hence in the glossary the expression is taken to refer to stalk.

In other instances where some difference of opinion has arisen, the significance of the term in ordinary language has usually been considered in coming to a decision regarding the shade of meaning of a term.

Some very useful and expressive terms in common use are difficult to define. Thus the significance of *quality* is hard to fix, for it seems to denote desirability in many ways or the presence of some flavour. Exactly how quality is obtained or destroyed cannot be said, although it is evident that only fine leaf gives quality teas.

Another common term is *point*. This cannot be tied down to any particular property, some tasters using it to denote any characteristic, strength, pungency, briskness, which is sufficiently marked to carry that property into a blend.

The exact meaning of *briskness* is difficult to define. Many tasters use it to denote a *live* liquor as opposed to a *flat* one, but whether it indicates a degree of pungency it is difficult to say. The terms live and flat are here used as they are in describing freshly opened soda water and soda water which has been allowed to stand for some time.

Pungency in a tea tends to leave the mouth raw after tasting. It is a characteristic of Assam and Ceylon high-grown teas. Dooars and Surma Valley teas are seldom pungent, but are usually brisk.

Many terms appear to be used to denote the same property or slight variations of the property. Thus, *washy, weak, thin, light* and *sweet* describe various degrees of thinness, the first two terms representing something very undesirable. The last two terms may be used to describe good liquors, although not so good as those showing thickness and strength. Some tasters use the term *sweet* to denote a liquor that is not coarse or common.

The terms *dry, bakey, high-fired* and *burnt* denote degrees of the same fault in ascending order of undesirability. The expression *malty* denotes a desirable quality, and this is also probably the result of a touch of the fire.

The terms *full, rich, ripe, round, smooth* and *mature* all indicate an absence of bitterness or rawness in the liquor and suggest strength. Such liquors usually cream down well. Fullness gradually gives way to *softness* and then *flatness*.

The expression *sweetish* is occasionally used to denote a tea which has some undesirable quality, probably a

taint. *Fruity* expresses a similar characteristic and suggests over-fermentation on an infected fermenting space. In general, *taints* arise from causes quite foreign to tea, e.g. oranges, onions, kerosene.

The seventy-four terms in the glossary which follows are collected under four headings dealing with the appearance of the tea, the infused leaf, the infusion or liquor, and general characteristics.

Terms Describing the Appearance of the Tea

Brownish—Leaf which is brown in colour. Under-withered leaf fired at too high a temperature produces a brownish tea.

Blistered—Leaf swollen and hollow inside. Blisters are formed in the second firing of leaf which has been too rapidly dried in the first fire.

Black—Leaf which is black in colour. Fully withered leaf gives black tea, but that produced in North-East India is not usually black in colour because of the light wither and certain other conditions of manufacture.

Bold—Indicates that the pieces of leaf are big, and that they might be cut smaller.

Choppy—Leaf chopped in the breaker or cutter rather than in the roller. Used in regard to a B.P. made by cutting a leaf tea, e.g. a Pekoe or O.P.

Clean—Leaf free from fibre and dust.

Crepy—Indicates that the leaf is crimped in appearance.

Even—Leaf true to grade and consisting of pieces of roughly equal size.

Flaky—Leaf which is not twisted, but in flakes. Results from the hard rolling of under-withered leaf, or from the manufacture of hard leaf.

Grey—Greyness results from too rapid firing or too much rubbing during sorting and cutting.

Silver tip—Grey coloured ' tip '. Over-withered leaf usually gives grey ' tip '.

Some ends—This is not a good term, and should be taken to mean some stalk although some tasters use it to indicate some ' tip '.

Stalk—Usually indicates the presence of red stalk. Results from coarse leaf and too hard rolling.

Tippy—Containing a large percentage of golden ' tip '. The hair on the young leaves smeared with fermented leaf juice is responsible for ' tip '.

Uneven—Tea composed of uneven, irregular pieces, indicating bad sorting.

Well twisted—Fully withered leaf gives well twisted tea.

Terms Describing the Infused Leaf

The tea taster uses the term infusion to denote the infused leaf.

Bright—Bright red in colour, denoting a good tea. The liquors from such infused leaf are also usually bright. This colour is referred to as the new penny colour.

Coppery—Bright copper coloured infused leaf, often given by second flush and autumnal teas.

Dull—Brownish in colour, denoting a poor tea. This is referred to as the old penny colour. Dull colours result from over-withering, over-fermentation or poor leaf. The liquors of such infused leaf are usually dull in colour.

Green—Greenish in colour. This characteristic results from under-withering, under-fermentation or insufficient rolling. The liquors from such infused leaf are raw or thin according to the fineness or coarseness of the leaf.

Mixed or *Uneven*—The infused leaf contains red, black and green colours. Results from uneven withering, fermentation or rolling.

Terms Describing the Liquors

The tea infusion is referred to by the taster as the liquor.

Brisk—Having a 'live' characteristic. May indicate some degree of pungency.

Bright—Bright and clear in colour. In the early season teas the brightness is of an orange tinge, and in the later teas a rosy red, clear colour.

Body—See *Thick*.

Colour—Denotes good colour, bright red and clear.

Dull—Brownish liquors, which are not clear or bright. May result from over-withering, over-fermentation or incorrect firing.

Flat or *Soft*—Lacking in briskness and pungency. Results from over-withering, over-fermentation or incorrect firing.

Fruity—Suggests a taint. May be due to over-fermentation on an infected floor.

Full—A strong tea with no bitterness. One which will cream down well.

Hard—Suggests pungency. This is a desirable quality met in Assam teas.

Harsh—An infusion which is bitter. Results from under-withering, under-fermentation, but generally from under-rolling.

Light—An infusion lacking body or thickness.

Mature—No rawness or flatness.

Muddy, Murky—Dull liquors suggesting over-fermentation.

Pungent—Having astringency without bitterness. This is a very desirable quality.

Raw, Rasping—See *Harsh*.

Rich, Ripe, Round, Smooth—See *Full*.

Strength—A combination of thick liquors and pungency or briskness. A strong tea creams down well.

Sweet—A light liquor that is not necessarily undesirable.

Sweetish—A term rarely used and one suggesting a taint.

Thick—A concentrated, bright red infusion which creams down well.

Thin, Weak, Washy—A dilute infusion of little value. Such liquors may result from under-withering, under-fermentation and not enough rolling. High temperatures during manufacture produce thin liquors. Thin liquors usually indicate poor leaf.

Terms Describing General Characteristics

Aroma—Denotes that the infusion and the infused leaf have one of a certain number of smells which are highly valued. Such aroma is connected with flavour.

Bakey—A slightly high-fired tea.

Burnt—A taste of burnt organic matter in the infusion and a similar smell in the infused leaf. Denotes too high firing temperatures, usually in the second fire.

Coarse—A liquor with certain undesirable characteristics. Results from coarse leaf.

Cream—The precipitate obtained as soon as a strong tea cools.

Dry—A characteristic in the liquor which is evident when tea is not discharged from the dryer as soon as it is fired.

Flavoury—A tea showing a taste associated with certain seasonal, district or 'Green fly' teas.

Gone-off—A mouldy or tainted tea, a flat or old tea. Usually denotes that tea has been packed containing too much moisture.

Hay flavour—A characteristic which often precedes autumnal flavour.

High-fired—A burnt tea but one not so badly high-fired as to be described as burnt. Results from keeping tea in the dryer at 200° F. or more after it is fully fired.

Malty—A desirable quality. May be due to slight high-firing.

Mushy—A soft tea, suggesting it has been packed too moist.

New—A tea which has not had time to mellow. Usually denotes some rawness in the infusion which may disappear when the tea is kept.

Nose—Indicates some aroma. Maltiness is noticeable on the nose.

Plain—Lacking in tea characteristics. Suggests coarse leaf.

Point—Some marked desirable characteristic, perhaps briskness.

Quality—Denotes the presence of desirable characteristics.

Smoky or *Tarry*—Tastes of smoke. May be due to leaky tubes in the stove which allow furnace smoke to enter the dryer. In some China teas this is a desirable quality.

Stewed—A dull tea with a taste reminiscent of stew. Results from faulty first firing usually.

Sweaty—Tastes like sweat smells. May result from over-fermentation on an infected floor.

Tainted—A tea having a strange flavour. May result from infection by micro-organisms at some stage of manufacture or on keeping. Usually refers to some flavour quite foreign to tea, e.g. oranges, onions, kerosene.

Weedy—A grass or hay flavour which is undesirable.

CHAPTER XVI

TEA IN NORTH AND SOUTH INDIA

Tea in Ranchi—Dehra Dun—Crop distribution—The Kangra Valley—Tea in South India.

TEA in North India includes the three small and widely separated areas of Ranchi, Dehra Dun and the Kangra Valley which, although not of great commercial importance, are nevertheless of interest. South India contains a considerable acreage under tea which is being rapidly extended. Unlike the other areas, South India has a great future before it.

The area under tea in each of the districts now under discussion is shown below, together with that in North-East India. Crop figures are also shown and, like those of the planted acreage, refer to the year 1931.

	Acres	Production million lb.
North-East India	640,190	333·49
Ranchi	2,089	0·72
Dehra Dun	6,254	1·37
Kangra Valley	9,693	1·90
South India	149,207	56·60
Total	807,433	394·08

TEA IN RANCHI

Ranchi is about 400 miles west of Chittagong, on the opposite side of the Bay of Bengal, about 150 miles from the coast. It does not lie within the track of the moist air drift which passes into North-East India to alleviate the spring drought. The climate of Ranchi

is hence hot and dry before the arrival of the monsoon, and resembles that of Calcutta. Details have been given in an earlier chapter.

The Ranchi tea gardens are situated on the Chota Nagpur plateau, near the town of Ranchi. This plateau is part of the geologically ancient Deccan, and the rocks are mainly crystalline schists, quartzites, gneisses and granites of the Archaean age. The plateau is about 2,000 feet above sea level.

Between Ranchi and the adjoining Hazaribagh district runs the Damuda Valley. When the coal fields of this area were developed, a need for pit-props was created which led to the wholesale deforestation of the Chota Nagpur plateau. The probable effect of this on the climate has been mentioned.

Tea was first planted in the Ranchi district at Hotwar and Palandu in 1862. The acreage at first rose steadily to about 2,300, but for the past 20 years a gradual decrease has taken place. It is almost impossible to put out fresh tea or to infill vacancies with success. Only under dense shade will infillings thrive and then not in a manner to yield well. Deforestation is held responsible for the failure of new areas, and Ranchi tea may be expected eventually to disappear.

The area under tea consists of a number of detached gardens, of about 100 acres each, which are amalgamated into groups sending leaf to a central factory. Since the Ranchi district is a popular recruiting area for labour for Assam, there are plenty of returned garden coolies in the district with a knowledge of tea, a fact of considerable importance to the tea growers there.

The variety of tea grown in Ranchi is China, for bushes of the Assam type are unable to withstand the climate. The average yield is about 160 lb. per acre, although good sections may yield up to 400 lb.

The Ranchi soils are sandy loams of a lateritic nature. They are generally poor in organic matter compared with soils of a similar texture in Assam, and are moderately acid. The average total nitrogen content is about 0·07 per cent, the available phosphoric acid about 0·01 per cent and available potash about 0·015 per cent. The available lime varies between 0·05 per cent and 0·01 per cent.

For climatic reasons methods in Ranchi differ considerably from those in North-East India. The difficulty, in fact almost impossibility, of putting out nurseries in Ranchi has already been mentioned. If a plant is established it comes into ordinary bearing in 8 to 10 years.

The bushes are pruned every third year about mid-May. If the bush is pruned earlier in the year, the new growth dies back during the pre-monsoon drought. After pruning, little crop is obtained until October. During the second and third years the bush is in full bearing, but the crop tails off in the spring of the fourth year. Good areas will give 40 lb. tea per acre in the year of pruning, by the end of that season; 400 lb. in the second and 260 lb. in the third year, the last two years being unpruned. It often happens that in an extra bad spring drought the one-year old wood dies back and a new frame has to be built up again.

The bushes are pruned up three times over a period of 9 years, then they are cut back. They might be pruned up longer but for the fact that in 9 years there is practically certain to be a drought which kills the wood right back.

The tea in Ranchi is plucked every 8 days. The first plucking is at about 19 inches from the ground on low pruned tea, and on 3 inches of new wood, i.e. three leaves on the China variety of bush, on top pruned tea. In the second flush one leaf is left, and in the third flush plucking is to the *janum*.

So far as cultivation is concerned in Ranchi, matters are easy on account of the comparatively slow growth of weeds. A soil mulch is essential in the dry season, but even then it dries to a depth of about 18 inches. Drains do not appear to be needed.

Shade is provided by the mango, toon, sirris, sau and many other trees. Boga medeloa, sunn hemp and cowpeas are used as green manure. Artificial manures are also used.

Pests and blights give little trouble in Ranchi and the wood of the bushes appears extraordinarily clean and free from parasitic growth. The severe drought no doubt reduces disease.

Practically all the leaf in Ranchi is made into green tea which brings a good price in the Calcutta market.

When leaf is brought to the factory it is placed in a revolving wooden case into which steam is blown for about two minutes. By this means the leaf is killed and fermentation rendered impossible. Leaf brought in late in the afternoon is spread thickly in a cool place overnight and steamed in the morning.

When the steamed leaf is cooled somewhat it is put through a hydro-extractor to remove the superficial moisture, although during this process some of the leaf juices are also removed and a considerable amount of solid matter lost.

The leaf is next rolled for 35 minutes without pressure and then fired till it is roughly a quarter dry. A moisture estimation on leaf dried to this stage showed it to contain about 50 per cent moisture. A second roll is then given, with pressure, for about 45 minutes after which the firing is continued. The leaf is finally fired in a Gibbs and Barry or Gibbs and Winsland machine. This type of machine consists of a long revolving cylinder, set at an angle which can be adjusted, fitted with vanes and

baffles. Hot air is passed into the lower part of the cylinder through which the leaf gradually works its way against the incoming air, receiving some twist and its final drying.

The tea is polished by placing it in a steam heated revolving cylinder with powdered soap stone. Polishing is done for about 3 hours before and 5 hours after sorting.

Tea in Dehra Dun

Dehra Dun is situated in the United Provinces at the western end of Nepal, about 650 miles from the Bengal terai which is at the eastern end of that country. Dehra Dun is about 800 miles from the Bay of Bengal and the same distance from the Arabian Sea. Its proximity to the Himalayas profoundly influences the Dehra Dun climate, making it cooler and more humid than the plains a few miles distant. Part of the monsoon rain comes from the Bengal current and part from the Bombay side.

The Dehra Dun tea gardens are all situated in the *dun* or valley between the Himalayas and the Siwalik Hills. The formation of the Siwaliks is of interest. The central axis of the Himalayan range is buttressed on either side by an immense depth of sedimentary strata which has been washed down from the crest line by the action of seas and rivers. The whole of the Himalayas appear to have advanced southward and, as a result of this lateral thrust, the Siwaliks have risen. They are thus composed of the same material as that forming the level plains of north India and the Siwalik zone was formerly the northernmost belt of the great alluvial region.

The most recent deposits of stones and gravel have raised the level of the Dehra *dun* about 1,000 feet above

the plains to the south of the Siwaliks. Dehra is about 2,000 feet above sea level. The Siwalik range rises to about 3,000 feet on the south side of the *dun* and the Himalayan foot hills to about 8,000 feet on the north. Mussoorie is situated on the foot hills above Dehra Dun at a height of about 7,000 feet.

Dehra Dun is one of the historic areas in tea development in India. The committee appointed by the Governor-General of India in 1833 to consider the question of tea growing in India recommended the lower hills and valleys of the Himalayas (indicating Mussoorie and Dehra Dun) as the most suitable places for tea cultivation. Accordingly, in 1840 a Government tea plantation was started at Kowlagarh, near Dehra Dun. In 1851, Robert Fortune, at that time an authority on tea in China, inspected Kowlagarh and reported unfavourably on the site and the tea, and condemned irrigation, apparently on the ground that it was unnecessary in China. Present day experience in Dehra frequently shows that irrigation of tea is harmful on account of the alkalinity of the water used for the purpose.

The tea industry in Dehra Dun has developed slowly, with ups and downs parallel to those experienced in other parts of India. To-day, tea in Dehra Dun is in a sound position and able to pay good profits.

The Dehra tea soils are of an alluvial nature, resembling in texture many of the Assam soils. They are well supplied with organic matter and plant food, but have the serious drawback, so far as tea is concerned when planted on soils of this nature, of lacking acidity. Although the tea grows well, its development is slow and its yield, compared with that of Assam, poor. This lack of acidity is shown by all Dehra tea soils and also by several taken from the neighbouring Sirmur and Nahan States.

The average nitrogen content of the Dehra tea soils is 0·1 per cent, and available phosphoric acid and potash both about 0·01 per cent. The available lime shows a wide variation with the limits about 0·05 per cent and 0·2 per cent.

The variety of tea grown in Dehra is generally China hybrid, but the Burma variety will also thrive. The average crop is about 450 lb. per acre. The gardens usually consist of consolidated areas of 250 to 500 acres, although several much smaller concerns exist.

In this area excellent nurseries may be obtained and a percentage of infillings live, if they are carefully tended.

Pruning is carried out annually from November to February. The common pruning cycle begins with a heavy prune, after which the bush is left unplucked or lightly plucked during the following season. The next cold season the bush is cut between 24 and 30 inches. Top pruning on about one inch of new wood is then practised annually for the next 10 years or more, after which, when the crop begins to fall off, the bush is heavy pruned again. This treatment produces a frame with thin wood and little spread. If a bush is middle pruned, there is a probability that it will die back. In some cases, however, middle pruning has given excellent frames comparable with those obtained in Assam.

Plucking is carried out about every twelve days and a leaf is left at each plucking. The first plucking is made on about 4 inches of new wood.

The commonest and best shade in Dehra Dun is the shishum (*Dalbergia sissu*). The dhak or palas (*Butea frondosa*) and toon are frequently employed. The use of green crops is common and of recent years there has been some use of artificial manures.

Pests and blights are not serious in Dehra Dun.

Practically all the leaf in Dehra is manufactured into green tea, which is usually sold in bulk at the garden factory to Indian merchants. After some bargaining the price is agreed upon, and the tea then packed in bags and taken to Amritsar, the tea mart for the North-West. Here it is sorted and repacked for Kashmir and the Frontier. One or two breaks are sold each year in Calcutta by the bigger concerns.

In Dehra, the preliminary sterilization of the leaf is carried on in pans heated to a dull redness by wood fires. About 15 lb. green leaf is thrown into the pan and kept stirred with a stick for 3 or 4 minutes. At the end of this time about 2½ lb. moisture has been driven off and the leaf has turned olive green. Hard or old leaf is burnt in the pan or fails to take on the correct colour.

The leaf is then rolled for about half an hour and spread on cement in the sun to dry partially, during which time it turns a blackish-green colour. If there is no sun for drying, the leaf is put through a drying machine and dried just short of crispness. Another roll is then given, followed by a final fire. The finished tea is not polished.

Crop Distribution in Ranchi and Dehra Dun

In the light of what has been said regarding climate and methods in Ranchi and Dehra Dun, it is of interest to compare the distribution of crop throughout the season in these areas with that in North-East India.

The spring crop in both Ranchi and Dehra Dun depends on the early rain which is liable to considerable variation. After the spring flush the bushes grow very slowly for a time on account of the hot dry period preceding the monsoon, but with the break of the rains growth is again rapid and continues so for 3 or 4 months.

In the Brahmaputra Valley the spring is cooler than in Ranchi or Dehra Dun and the early rains merge into

the monsoon without any serious intervening drought. On account of these differences the spring flush develops later than in North India and there is not the same marked hiatus between the spring and subsequent flushes.

In considering the distribution in Ranchi it is necessary to remember that one-third of the area is pruned in May, which may be thought to depress the June crop somewhat. In Dehra Dun, however, the whole area is pruned in the cold weather, but in spite of this the falling off in May and June is as marked as in Ranchi.

The tea in the case of the Brahmaputra Valley crop considered in the table below is all pruned in the cold weather. If part had been left unpruned a more even crop distribution would have been obtained. It will be seen that the half season occurs towards the end of

Table showing Crop Distribution throughout the Season

	Ranchi	Dehra Dun	Brahmaputra Valley
	%	%	%
January	nil	nil	nil
February	1	nil	nil
March	6	1	nil
April	16	20	2
May	6	7	4
June	7	3	11
July	16	15	15
August	15	21	20
September	14	17	20
October	12	11	19
November	5	5	9
December	2	nil	nil

August. In the Dooars and Surma Valley the season starts somewhat earlier on account of the warmer spring, and the half season is accordingly reached at an earlier date than in the Assam Valley.

In many gardens of the Surma Valley and the Dooars as much as one-third and often more of the area is left unpruned. In such cases it is common to gather 20 per cent of the crop in April or May and half the total crop may be made early in July.

The table shows the percentage of the total crop made each month in Ranchi, Dehra Dun and the Brahmaputra Valley.

Tea in the Kangra Valley

The Kangra Valley is situated in the Punjab at a distance of about 200 miles from Dehra Dun. The valley is in the foothills of the Himalayas and connected with the Kulu Valley, renowned for its orchards. Fruit is not grown in the Kangra Valley, it is said, on account of the liability to hailstorms at blossom time. The main tea growing area is near Palampur, about 70 miles from Pathankot at the entrance to the valley from the plains, and about 200 miles from Amritsar.

The cultivation of tea in this district began in 1860 when land was sold for tea cultivation, mainly to British officers. Competition from Assam was severely felt, and the slump in tea prices about 1900, followed by the big earthquake in 1904, drove most of the British owners and managers from the district. The tea then passed to Indians, who were often absentee owners.

Little new tea has been planted since 1900, and that remaining is at present in a debilitated condition. The tea is of the China and China hybrid varieties, although experimental areas of the Assam type appear to grow equally well.

No reliable meteorological observations for Palampur are available, but the few records to hand show an annual rainfall of about 100 inches, unevenly distributed. It is generally considered that the climate is too cold and dry for very successful tea growth.

The tea soils of the Kangra Valley are of two types, a grey sand and a red clay. All the tea soils examined have been found to be only slightly acid or neutral, and in this respect unfavourable to vigorous tea growth.

Neither field work nor manufacture are carried out in Kangra with the same care that is practised in other districts. Systematic manuring is not common. The slopes of the hills are well terraced and little soil is lost by erosion.

Systematic pruning is not done, and in plucking, shoots are taken from all parts of the bush as they grow. As a result, most of the crop is made early in the season.

The leaf is made into green tea which is sent to Amritsar.

Tea in South India

Although the tea industry in South India is a modern one, this area was early the scene of experiment. When in 1834 Lord William Bentinck sent a commission to China to obtain seed and expert tea makers, many of the plants were sent to South India. They were planted in the Nilgiris, chiefly at the experimental farm at Kaity, and in 1839 they were reported to be growing luxuriantly. Another report, made in the same year, speaks of success in the Wynaad.

Not till 1853 was the production of tea on a commercial scale taken up in South India, although the industry made little progress. Thirty years ago the area under tea in the Nilgiris did not exceed 3,000 acres, 250 acres in the Wynaad, 315 acres in the Kanan Devans

and perhaps 5,000 acres in the rest of Travancore. Of the 133,000 acres of tea in bearing in South India to-day at least 122,000 have been planted since 1893. The present distribution of mature tea is as follows:—

	Acres
Madras Presidency:	
Nilgiris	16,237
Nilgiri-Wynaad ..	10,502
Wynaad	12,340
Anamalais	23,504
Mysore	3,134
Coorg	415
Travancore:	
Central (Peermade) ..	25,373
Kanan Devans (High Range)	28,500
Mundakayams ..	3,063
South	9,619
Total	132,979

The geography of the tea districts of South India is briefly as follows. The Eastern and Western Ghats meet about the Nilgiris, where they rise to a considerable height. The Nilgiri tea district ranges from 4,000 to 6,000 feet. The Nilgiri-Wynaad is situated lower down the slope whilst the Wynaad is an area of low elevation.

To the south of the Nilgiris is the Palghat gap at an elevation of about 1,000 feet, in which is situated Coimbatore. South of the gap the land rises again to the Anamalai and Cardamom Hills. On the slopes of the Anamalais is the tea district of that name, whilst higher up, on the Kanan Devans, is another important tea area, often spoken of as the High Range, at an altitude of about 5,000 feet. Central Travancore, spoken of as the Peermade, lies above South Travancore, which latter is a district of low elevation.

Planting conditions in South India resemble those in Ceylon, and the methods both in the field and the factory

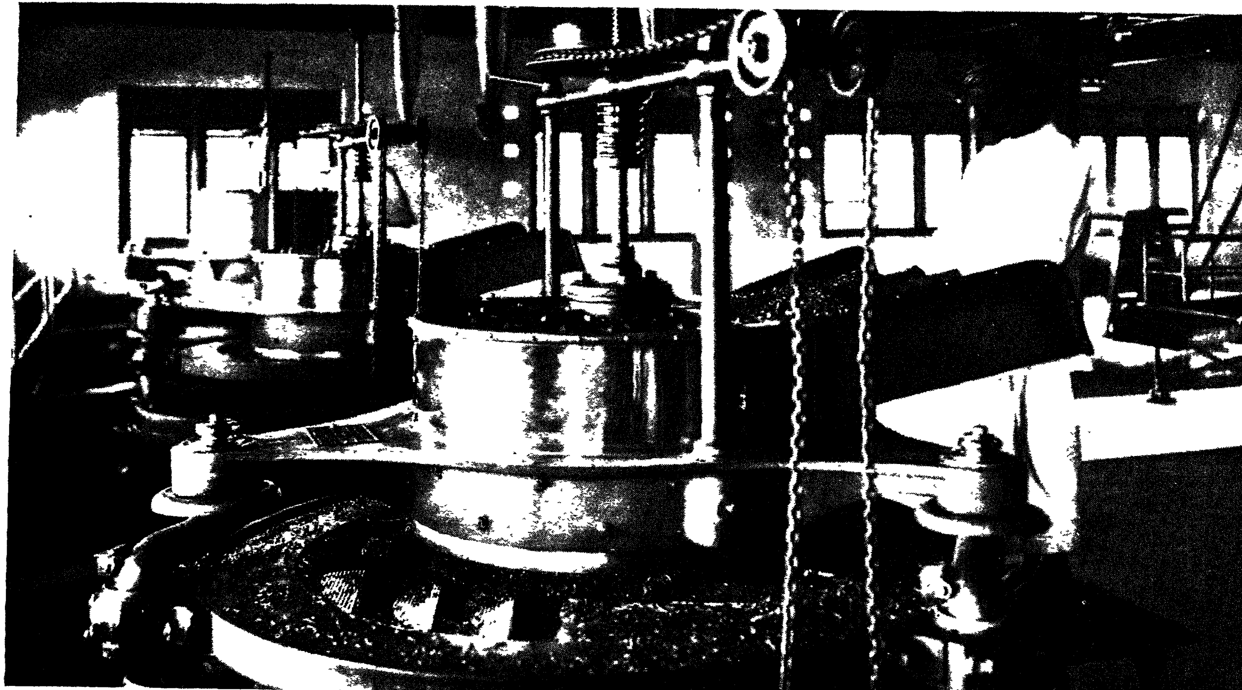
have been introduced by Ceylon planters who have been largely responsible for opening up this area.

South India has the advantage of labour available in the area, which, combined with the fact that there is plenty of land still to be had for planting, makes it likely that this will be one of the great tea areas of the future.

A Scientific Department for tea in South India was opened in 1925, with a station in the Nilgiris. Methods and requirements in South India so closely resemble those of Ceylon that there is a movement on foot to amalgamate with the latter in the matter of scientific research.

Before closing this very brief discussion on tea in South India, some observations on the market value of teas from this area may be made. The average price of South India teas is much below that of Ceylon and slightly less than that of the average in North-East India. Reference to the table in Chapter XX under the section, 'The Wholesale Price of Tea', will supply details on this subject. Some of the High Range and Nilgiri teas bring good prices, only slightly under those of high-grown Ceylons, but the average for South India is considerably lower than might be expected.

Although the reputation of Ceylon teas may give them some advantage in the market over those of South India, it is clear that, apart from this, there is a very real difference for which it is difficult to account. In most apparent respects, such as soil, climate and average altitude, conditions in South India resemble those of Ceylon. The fine teas show the same low tannin content observed in similar teas in Ceylon, yet the general high standard of quality is missing. It is evident that one or more of the important natural factors making for quality in tea are still unknown.



ROLLING THE LEAF

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CHAPTER XVII

TEA IN CEYLON

The Ceylon tea country—Statistics—The climate of Ceylon—Ceylon tea soils—Planting, pruning and plucking—Manuring and cultivation—Pests and blights—Manufacture.

CEYLON is a pear-shaped island lying to the south of India. From north to south it measures about 300 miles, and at its widest about 150 miles. Kandy is the ancient capital, and Colombo the present one and also the port and business centre of the island.

Ceylon is composed of a wide coastal plain with a considerable mountain area in the centre, rising to a height of over 8,000 feet. The tea is planted mainly in the mountains of the Central province, although the foothills and low-lying country to the west, in the province of Sabaragamuwa, contains much tea. Certain parts of the Uva province also contain important tea areas.

THE CEYLON TEA COUNTRY

From the point of view of compactness and communications, the tea districts of Ceylon resemble those of Java and offer a distinct contrast to those of North-East India. Hatton, in the centre of the tea country, is only seven hours by rail from Colombo, whilst Badulla, at the end of the tea districts, is only 180 miles away. Ceylon has excellent roads and an extensive telephone system.

During the train journey from Colombo to Badulla a good idea of the general lie of the land in the planting districts is obtained. For the first 50 miles or so the railway runs through rice land broken by hillocks of red soil. Soon after the line begins to rise the planting

district is entered and cacao, rubber, cardamoms, cocoa-nut and other crops are seen growing. Kandy is situated at an elevation of 1,600 feet, and as this town is approached tea becomes more frequent. In the Kandy district it is common for a planter to have charge of an estate producing three or even more different crops.

Above Kandy the line runs through a series of narrow valleys almost wholly occupied by tea. Above Nawalapitiya the last rubber is seen and thence onwards the hill slopes, right to the crests, are generally covered with tea bushes. Many of the hillsides seem to be little more than rock with bushes perched precariously on small patches of soil.

The Dikoya district through which the railway runs was formerly an important coffee area. Much of the tea is planted up on old coffee land, partially exhausted and considerably eroded. Many of the factories are relics of the coffee days, and are situated at the bottom of the valley in order to utilize water power. There is a move nowadays to rebuild factories higher up the slope where better quality tea can be made owing to lower temperatures.

The Dimbula district is said to be the finest in Ceylon, and adjoins Dikoya. Much of the land here is above 4,000 feet and the nature of the vegetation shows a distinct change from that in lower elevations. On the tea estates the most notable change is the substitution of acacia shade trees for the dadap.

From Nanu Oya a narrow gauge line runs to Nuwara Eliya and on through Kandapola to Ragalla. These districts contain some of the finest and highest tea estates in Ceylon. At present no jungle area above 5,000 feet is granted by Government for tea land, but much of the tea already planted is above this altitude, and some is put out at about 7,000 feet.

Continuing on the main line from Nanu Oya, the highest point on the railway is reached at Pattipola, at an altitude of 6,225 feet. It is about here that the *patanas* or grassy downs of the Uva district are entered. During June or July, when the south-west monsoon is beating against the mountain side, it is a common experience to enter the Pattipola tunnel in mist and rain and, in a few seconds, to emerge into brilliant sunshine on the other side of the island divide.

The Uva district is served mainly by the north-east monsoon, and the planting season accordingly differs from that on the south-west side of the divide.

The low-grown tea of Ceylon is planted on the south-west or wetter side of the mountains, the chief district being the Kelani Valley. During the rubber boom in 1910 much of the lowland tea was interplanted with rubber which has practically stifled the tea. Although the tea in this area is called low-grown, it is actually planted on hillocks, often as steep and rocky as the slopes in the high country.

Statistics of the Ceylon Tea Industry

In 1875 coffee was the chief crop planted in Ceylon. About this time the coffee plant was attacked by a leaf disease (*Hemelia vastatrix*) the danger of which was only realized after it had spread throughout the country and got beyond control. In a few years the coffee acreage was reduced from 300,000 to 50, until the industry ceased to be in Ceylon. Following this failure, cinchona was planted, but after a few years, owing to over-production and competition from Java, this crop was no longer a paying one.

Tea was first planted in the '60s, and by 1875 about 1,000 acres had been put out. The course of the subsequent development is shown in the following table.

	Acres
1875	1,080
1895	305,000
1905	390,000
1915	402,000
1924	440,000
1929	450,000

The last figure does not include small holdings, which are said to total about 20,000 acres.

With the planting of rubber much of the tea in the lower areas was uprooted or deteriorated under rubber trees, but this was compensated for by fresh areas opened out in higher elevations. At present it is considered that the tea acreage has reached its limit, although there is still much *patana* land available.

Most of the tea is situated above 3,000 feet. Tea in the Kandy district is called 'medium-grown', and that about 4,000 feet 'high-grown'. More than 37 per cent of Ceylon tea is in the Kandy district, 23 per cent in Nuwara Eliya, and 18 per cent in Badulla. Less than 20 per cent of the tea is 'low-grown'.

The average size of a tea estate in Ceylon is 327 acres, compared with 460 acres in North-East India. The yield varies from about 700 lb. tea per acre in the low country to 300 or 400 lb. in the high-grown areas.

The average price of Ceylon tea is considerably higher than that of India or Java. The prices vary with the season and elevation. The best teas are made in January, September and October, and the poorest in June and November. The low-grown teas generally bring a slightly higher price than the medium-grown, partly on account of better make. The teas are sold by auction in Colombo, or shipped thence to London for auction.

The tea industry in Ceylon is highly organized, in a manner similar to that in North-East India. Labour is largely recruited from south India.

The scientific research for the industry was previously conducted by the Government Department of Agriculture. In 1925 a separate organization known as the Tea Research Institute of Ceylon was formed to carry out research work connected with tea. Much pioneer work on the science of tea was carried out by M. Kelway Bamber in Ceylon from 1890 onwards, whilst in later years T. Petch made notable additions to the knowledge of the fungus diseases attacking tea.

The Climate of Ceylon

A general account of the climate of Ceylon has already been given. The year may be divided into four seasons, the two monsoon periods and the intermediate periods. At Colombo and Ratnapura both monsoons are distinctly marked. After the weakening of the south-west monsoon in July the precipitation again increases in October, which increase is attributed to the advent of the north-east monsoon.

Kandy, occupying a central position in the island and not cut off on either side by high mountains, gets a fairly evenly distributed rainfall in addition to generous precipitations from both monsoons.

Nawalapitya is the wettest area, being at the optimum altitude for rainfall (about 4,000 feet), and receives an average of 271 inches. Nuwara Eliya escapes the full effect of both monsoons but is liberally treated by both.

Badulla, in Uva, is on the east side of the rain divide and receives most of its rain from the north-east monsoon. The effect of the rain divide is well seen from Haputale. During the south-west monsoon, the cloud bank can be seen rolling up to the hill summit and just spilling over into the Uva district, and as the clouds descend into the warmer atmosphere they disappear. On some estates which are actually put out on the rain divide, a short

walk may take one in and out of the monsoon several times.

Average Monthly Rainfall at Various Stations in Ceylon

	Colombo	Ratna-pura	Kandy	Nawala-pitiya	Nuwara Eliya	Bad-ulla
	in.	in.	in.	in.	in.	in.
January	3·4	5·3	5·2	8·2	5·7	9·7
February	1·8	4·4	2·2	3·7	2·0	3·0
March	4·3	8·6	3·9	5·1	3·3	4·3
April	9·7	12·5	6·8	7·9	5·7	7·5
May	10·7	17·6	5·4	13·8	6·6	4·5
June	7·2	20·0	9·6	65·8	12·9	2·3
July	4·5	12·9	7·5	38·5	12·1	2·0
August	3·1	11·9	5·7	39·6	7·9	3·2
September	4·7	15·0	5·9	40·7	8·3	3·4
October	13·4	18·9	11·8	24·6	11·1	9·9
November	11·6	14·3	10·6	16·4	9·0	10·5
December	5·1	8·8	9·1	6·6	8·6	12·4
Total	79·5	150·2	83·7	270·9	93·2	72·7

The heaviest flushing months all over the island, both in the south-west and north-east monsoon areas, are March, April and May. During the first six months of the year many estates may produce two-thirds of the crop. During June, July and August, when the monsoon is blowing hard and the rain falling in torrents, the crop is poor. An idea of the unevenness of the crop distribution is given by the following outturn of finished tea on one estate. The total crop was 800,000 lb. and of this 130,000 lb. were made in April and only 60,000 lb. in July.

After August the crop increases to a second maximum in November. December, January and February are again poor months in the south-west monsoon area,

although in Uva, November, December and January are good cropping months because of the north-east monsoon rain.

Neither hail nor cyclones do any serious damage to tea in Ceylon, although strong winds are common and necessitate wind breaks. At times the wind is strong enough to strip bushes of their foliage. In the highest districts frosts are experienced and, if severe, may blacken the bush, but it is said that frost puts quality into the tea.

A dry wind is considered to give pungency and flavour. The teas all over the island are poor during the rush months, March to May, after which quality comes in Uva, where the south-west monsoon blows dry. Uva teas are poor in quality during the humid period of November to January when the north-east monsoon is blowing, whilst the Nuwara Eliya district gives flavoury teas in January, for here the north-east monsoon blows dry.

It is generally seen that in factories so situated that a good natural wither is obtainable, good teas can be made with greater ease than in those where an artificial wither is always necessary.

Ceylon Tea Soils

The Ceylon rocks, excepting those in the north and those round the coast, belong to the Archaean period of geology and are related to the Charnockite gneiss and granites of southern India. Round the coast of Ceylon, where most of the cocoanut plantations are situated, the soil is sandy. Towards the interior it gets heavier and the amount of 'kabuk' or laterite increases. The best and some of the heaviest soils are found near Nuwara Eliya.

The tea lands may be divided into three classes: forest, *patana* and *chena*. The last is land which has been

burnt by the natives before cultivation, and resembles the *jhumed* land of Assam, and is not planted if other land is available. The forest areas are preferred, of course, but since these are no longer available the *patanas,* where the soil is poorer and less deep, are being opened up.

Practically all the tea soils have been formed *in situ* from the rocks beneath them. Most of the soils are red in colour, but in many places quartz appears, forming light coloured patches. There has been considerable soil erosion in the past, and on this account many of the present tea soils are not indicative of the original soils.

Broadly speaking, the forest soils in the tea districts are gravelly loams, with a small percentage of clay of the non-sticky type, common in soils of a lateritic nature. The insoluble silicious matter varies from 50 per cent to 75 per cent and the oxides of iron and aluminium from 15 per cent to 30 per cent. These soils show pH values ranging from 6·4 to 7·4.

An idea of the chemical constitution of the normal Ceylon tea soil is given in the following table.

Table showing Chemical Constitution of Ceylon Tea Soils

	Kelani Valley	Matale	Nuwara Eliya	Badulla	Haputale
	%	%	%	%	%
Loss on ignition	11·86	12·39	13·30	8·18	6·06
Oxides of iron and aluminium	22·00	19·25	21·92	20·41	23·31
Sand and silicates	65·74	56·49	63·82	71·12	70·24
Lime	0·10	0·05	0·27	0·20	0·04
Nitrogen	0·16	0·14	0·41	0·09	0·14

The average Ceylon tea soil contains essential plant food in the following quantities. Nitrogen from 0·1 to 0·15 per cent, available potash from 0·01 to 0·015 per cent and available phosphoric acid about 0·005 per cent.

Except in the Bogawantalawa district there are no tea soils in Ceylon to compare with the peat soils of Cachar. A soil sample from Bogawantalawa with 0·799 per cent nitrogen came from an area which gave a crop of over 2,000 lb. tea per acre, a figure of the same order as that obtained from the Cachar *bheels*.

Planting, Pruning and Plucking

Tea seed is not imported from India to Ceylon on account of the risk of the introduction of Blister blight (*Exobasidium vexans*). It is said that the spores may be carried within the seed, in which case disinfection would be useless. As a result of this restriction local seed is grown in increasing quantity.

Seed is usually germinated and put out in shaded nurseries. Both dark and light leaved Assam varieties are common, but the usual bush is a medium hybrid, which stands the climate better than other varieties. The plants are transplanted at about 18 months, usually as a ‘ stump ’ which has been cut in the nursery.

The planting season varies with the district. In the south-west monsoon area it is June, July and August, and in the Uva province, where the north-east monsoon is the wettest period, the planting season is during this monsoon, November to January.

The young bush may be formed either by collar pruning or by centring. Plucking is continuous throughout the year and bushes are not pruned annually. In the low country, pruning is done about every 18 months, in the medium country once in two or three years, and in the high country once in three or four years.

Pruning time must be regulated to avoid the drought and the winds during the south-west monsoon. On the south-west side, pruning is carried out from mid-June to mid-September, but in parts where there is no

drought it may be carried on at any time during the year. In the Uva district, pruning is done in November. A young plant, unless it is cut in the nursery to about 4 inches, is often unable to stand the wind pressure in the monsoon.

Old tea is seldom collar pruned, but very low pruning is common. Cutting the bush lightly across or 'skiffing' is not practised in Ceylon, since conditions do not necessitate this procedure.

In the low country a bush may be brought into full bearing in about five years, and in the high country in six or seven years.

After pruning, the bush is out of commission for a period varying according to the altitude. In the low country the bush is 'tipped' from 6 to 8 weeks after pruning and the first flush is ready about 11 weeks from pruning. In the mid-country it is common to 'tip' about three months after pruning, and in the high country the period is still longer. The bushes are often 'tipped' at a height of about a foot from the ground, but since at subsequent pluckings a leaf is left, the bush gets steadily higher. When the time for pruning arrives, this is usually done 2 or 3 inches above the last cut. It is common to prune up three times and then to prune down.

A 7-day pluck is aimed at, and the leaf is usually very fine. During the second and third years after pruning the plucking period may lengthen to 8 or more days. After three years or so of plucking, the bush may have crept up 3 or 4 feet on the 'tipping' and it may have to be pruned because it is too high to pluck. A bush generally shows a need for pruning by producing a large proportion of dormant (*banjhi*) shoots. It is customary for the last few rounds before pruning to pluck harder than usual.

The annual yield after pruning varies, rising to a maximum and then falling. Thus on one of the high-grown estates the following crops were obtained :—

First year	after pruning	500 lb.	tea	per acre
Second year	„	„	900 lb.	„
Third year	„	„	950 lb.	„
Fourth year	„	„	850 lb.	„

Manuring and Cultivation

The manuring of tea is a much older practice in Ceylon than in India. The reason for this is probably because much tea was put out on old coffee land which was partially exhausted.

The pruning mixture is added in February or March or a month before pruning. The second mixture is added about eight months after pruning. In general, manuring may be carried out at all times except during the monsoon. The common time for application is with the first rain.

Cattle manure is seldom used and liming is not practised. The manure mixtures used are often complex, and combine slow and quick acting manures.

A pruning mixture may be made up to supply the three constituents, nitrogen, phosphoric acid and potash, in amounts equal to 15, 35 and 15 lb. per acre respectively, whilst an ordinary mixture may contain the same constituents in amounts equal to 40, 15 and 30 lb. per acre.

The quick crop, like cowpeas, which can be grown and hoed in in eight weeks is not used in Ceylon. As shade and a source of green manure, dadap (*Erythrina lithosperma*) is the most popular tree below 4,000 feet. It grows best at about 1,600 feet, and is generally planted about 20 feet square and lopped at 12 feet. The lopping is done 3 or 4 times a year, once with deep cultivation when the loppings are buried, and at other times when

they are left as a mulch. It has been found that the weight of green loppings average about 10,000 lb. per acre with two loppings a year, 20,000 lb. with three loppings, and 23,000 lb. with four loppings.

Trials with *Gliricidia maculata* have shown that this tree gives almost double the loppings of dadap. It grows well up to about 2,500 feet. The Ceylon sau (*Albizzia moluccana*) is grown as shade up to 4,000 feet, and although it can be lopped it is not commonly used in this way.

In the higher gardens above 4,000 feet the wattle (*Acacia decurrans*) is used for shade and lopping, and the silver oak (*Grevillia robusta*) as shade and as a wind belt. The latter is not lopped. Blue gum (*Eucalyptus globulus*) is also used as a wind belt.

It is usual on Ceylon tea estates to clean weed the soil, and any weeds which appear are scraped up and burnt or collected and buried. Clean weeding leads to soil erosion, and in addition the organic matter which might be hoed into the soil when weeds are allowed to grow freely is missed. Arguments in favour of clean weeding include the fact that it is cheaper to keep the estate absolutely clean than to weed periodically.

Cultivation or deep forking is done with an English fork generally when the manures are added. The deeper the cultivation the less is the subsequent soil wash.

Pests and Blights

The Tea tortrix and the Shot Hole borer are the pests which cause most loss to the tea crop in Ceylon. The tortrix grub lives in the lower leaves of the bush, and at the third or fourth cast moves to the flush which is then enclosed in a web and ceases to be of any use as leaf. The tortrix may be controlled by collecting the eggs, and the establishment of a system of flight breaks is also

suggested as a means of control. The moth has only a short flight range and since it is carried by the south-west monsoon it is considered that a system of breaks would fairly well limit the area affected by the moth.

The Shot Hole borer bores holes in the branches and renders them useless as leaf bearers. It has been found that good cultivation and manuring decrease the effect of this pest.

The Kaluchura snail is a pest on the low country. Red spider is common in the higher levels during a drought. White ants are common in the Central province, where the attacked bush is dug out or, if it is not seriously eaten away, treated with solignum or creosote. The Tea mosquito occurs sometimes in the low country.

The fungus diseases of the tea bush have received considerable study in Ceylon. The leaf and stem diseases in general occur in much the same order of severity as in North-East India. Blister blight, however, which can do so much harm in India, is not known in Ceylon. Of the root diseases, Ustulina is the commonest and Diplodia the most serious.

Tea Manufacture in Ceylon

In Ceylon much of the tea is of the China and China hybrid variety. Growth is slow in the higher elevations, fine leaf is plucked and manufacture at all stages is carried out with great care. The low temperatures in the hills allow of a very full wither, the leaf is rolled slowly and thoroughly with great pressure, fermentation is carried out in the cool and firing is done at a low temperature. All these conditions tend to make for fine, quality teas of high value.

The fact that much of the tea is grown where temperatures are low produces leaf with a low tannin content.

In addition, the method of manufacture adopted tends to produce a tea low in tannin, and some of the finest Ceylon teas contain only about 6 per cent tannin against 12 per cent in India plains teas of similar fineness. Some of the Fannings from high-grown estates give particularly light flavoury liquors, a fact recognized by purveyors of certain blends of tea which are claimed to suit persons with weak digestive systems.

Ceylon teas are usually much blacker than India teas. This is partly due to the fuller wither given in Ceylon and also to the fact that the dry tea is sifted less than in India. Much of the sifting is carried out before firing.

Ceylon teas do not usually keep as well as those of India. This may be because they are not fired so fully or because the practice of firing in one operation does not give such a thorough drying as the double fire usual in India.

In many districts of Ceylon a natural wither within a reasonable time can rarely be obtained, and outside withering houses are not used. Of recent years many Ceylon factories have been rebuilt on modern lines, with lofts so arranged and equipped that the control of the air flow and temperatures is almost complete.

The value of controlled withering for all districts of Ceylon is a question still under discussion, and the installation of a controlled system may so alter the character of the tea that its market value falls, although the tea may not necessarily be poorer than before.

A slow wither generally makes for a strong tea with a coloury liquor. The installation of a controlled loft hastens the wither and makes for teas with thin pungent liquors and reduces strength and colour. It can thus be understood how control may well lose a certain market and reduce the value of a tea perhaps permanently or till other buyers take an interest in the new product.

Compared with good natural withering, controlled seems to lose some pungency, probably on account of the higher temperatures employed. It has been found preferable to wither in a loft rather than to prolong the natural wither indefinitely or to roll under-withered leaf. A very slow wither gives dull infusions.

Generally speaking, in Ceylon it is found that in quality periods a quick wither is advisable, e.g. 12 to 14 hours, and excellent teas have even been made with a wither as short as 4½ hours. The tea so produced is thin and pungent. A prolonged wither gives more colour, but at the expense of pungency, quality and flavour. In non-quality periods it is found better to wither slowly to produce colour and strength, rather than to wither rapidly to produce thin pungent liquors devoid of quality.

In Ceylon the leaf is spread very thinly on the racks or 'tats' in the loft, and a rate of 1 lb. to 12 square feet or more is usual. The surface of the rack is generally composed of hessian. The leaf is carefully picked over, and coarse hard leaf removed before spreading.

The arrangement of a factory with controlled lofts has already been described in the chapter dealing with manufacture in North-East India. The wither aimed at in Ceylon is a hard or full one, 100 lb. leaf being dried to 55 lb. or less.

It is common to roll the leaf four times in periods of 30 minutes, although at some of the higher elevations it may be rolled as many as eight times. Between each roll the leaf is put through a ball breaker. The fine leaf separated in this manner after each roll is taken to the fermenting room, so that at the end of the roll less than half the original bulk of the leaf may remain.

In Ceylon the rollers make about 45 revolutions per minute. Great pressure is exerted in rolling and on

this account considerable heat is developed in the leaf and temperatures above 100° F. are sometimes registered. In order to reduce this and so avoid loss of quality, experiments with cooled rollers are being undertaken.

Triple action rollers, with a roller cap that revolves, are in common use. Considerable study has been given to the battens fixed to the rolling table, and the question of their size, position, pitch and serration has received attention.

Fermentation is carried out on glass or cement racks which, in cool districts, are often placed on a breezy verandah, with the leaf thinly spread, perhaps not more than half an inch thick. Where temperatures are high, 'mist chambers' are used to supply cool humid air to the fermenting room.

The larger drying machines in use in North-East India are not often employed in Ceylon. This is partly because the crops dealt with are smaller and partly because the crop distribution in Ceylon is better than in India and necessitates less machinery. The smaller machines used in India are common in Ceylon, as are also several dryers made by Colombo firms.

Tea is fired in one operation in Ceylon, which is rendered practicable by the full wither of the leaf. The firing temperature is usually 180° to 190° F.

A few years ago experiments were made in drying tea in a blast of cold air. This object was achieved by passing artificially dried air over leaf at a temperature of about 65° F. A strong flavoury tea was obtained, but unfortunately it would not keep. Apparently heat, as well as drying, is necessary to give tea keeping qualities.

CHAPTER XVIII

TEA IN JAVA

The Netherlands East Indies—The tea industry in the Netherlands East Indies—The tea soils of Java—Planting, pruning and plucking—Manuring and cultivation—Pests and blights—Manufacture —Java teas.

IN the account of tea in Java which follows, passing reference is made to the industry in Sumatra. Other references to tea in the latter island are made in earlier chapters.

THE NETHERLANDS EAST INDIES

The Netherlands East Indies is the collective name given to a series of islands and island groups stretching from Further India to Australia, lying between latitudes 6° N. and 11° S. of the Equator. The maximum extent of the islands from west to east, from Sabang in Sumatra to Humboldt Bay in New Guinea, is about 3,125 miles. From north to south the maximum distance is 1,250 miles.

The Netherlands East Indies comprise the large islands of Java and Sumatra, the greater part of Borneo, Celebes, the western part of New Guinea and innumerable

	Square miles	Population
Java	50,762	36·4 millions
Sumatra	162,268	6·2 ,,
Borneo (Dutch)	213,589	1·8 ,,
Celebes	71,763	3·3 ,,
Rest of archipeligo	235,299	3·3 ,,
Total	733,681	51·0 ,,

small islands. The total area under Dutch control is 773,681 square miles, and this is inhabited by over 51 million souls (census 1926). The table above gives a survey of the area and population of the four largest islands and the remainder of the area, which is largely made up of Dutch New Guinea.

An idea of the size of this empire is given by comparing it with the area of the British Isles, which is 121,000 square miles.

Although Java is as yet the only well developed island, Sumatra is progressing rapidly and, with the other islands, will in time go to make this area one of the richest in the world.

Up to now the economic development of the Dutch Indies has been bound up with agricultural products. Native agriculture has for its chief object the supply of foodstuffs to the inhabitants, whilst estate agriculture works almost exclusively for export. The chief native crops are rice, followed by maize, then tapioca, sweet potatoes, peanuts and soya beans. One of the most important estate products is rubber, of which about a million and a quarter acres are planted, partly in Java and partly in the other islands. Sugar, coffee, tea and tobacco are also large industries. Java possesses the monopoly of cinchona and more than 90 per cent of this product placed on the market comes from the island.

Politically the Netherlands Indies forms part of the kingdom of the Netherlands, and the Dutch legislation is the highest lawful power. The Governor-General rules in the name of the Queen, and he is assisted by an official advisory body, the Council of the Netherlands Indies.

In 1918, a representative body known as the 'Volksraad' (People's Council) was formed, members of which

are partly elected and partly appointed by the Governor-General. The latter must consult the Volksraad on certain matters such as budget, colonial loans and so on.

Java is by far the most important island of the archipelago. Its length from east to west is 665 miles and its breadth varies from 33 to 120 miles. In size it is slightly smaller than England and Wales and in population it is also slightly less. The island lies entirely between the 6th and 8th degrees of south latitude, and is hence situated about as far south as Ceylon is north of the Line.

The flora of Java is tropical and resembles very much that of the wet part of Ceylon. In the mountain region a sub-tropical vegetation occurs.

The subterranean soil is ancient rock broken by many volcanoes, for Java is situated on or about one of the great fissures in the earth's crust, and the volcanoes form one of the outstanding features of the island. There are about fifty volcanoes in Java and the upper layers of the soil are, for the greater part, composed of volcanic material, generally of recent geological origin. Buitenzorg is situated between two magnificent cones, Salak and Gedek, both well over 6,000 feet high, and on the flanks of these two volcanoes many estates are situated.

Batavia, the capital of Java, has a population of about 355,000 of whom more than 37,000 are Europeans. The other ports are Sourabaya and Samarang which, like Batavia, lie on the low northern coast of the island. Bandoeng is a modern town situated at the base of the Pengalengan Plateau at an altitude of about 2,000 feet. Its location and climate are extremely pleasant, and this spot is a favourite one for Dutch people who retire and settle in the island.

The communications of Java are excellent. Railways and steam tramways run all over the island and the

electrification of much of the railway system is in progress. An extensive network of good roads is in existence. Java is connected with the other islands by frequent and regular services of Dutch steamers.

The native inhabitants of Java are of Malay stock and are Mongolian. Chinese and Arabs are the most numerous of the foreigners, although the Europeans total over 175,000. The great majority of the native population are Mohammedans which faith was introduced by the Arabs in the fifteenth century. Prior to this, the Hindu influence had been great, and the magnificent temple at Borobudur and other remains are relics of a former Hindu-Javanese empire.

The Tea Industry in the Netherlands East Indies

The introduction of tea into Java and the subsequent development of the industry was along lines parallel to those followed by the industry in India. About 1690, Camphys, the Governor-General in Java, planted the first tea in that country purely as a matter of interest, just as Captain Kyd did in India in about 1780. In 1728, the Dutch East India Company seriously considered the planting of tea in Java, as the British Company did in 1788. Neither of these schemes was carried through, and it was not until 1825 in Java and 1835 in India that tea, as an industry, may be said to have started.

In 1825, the Dutch Government ordered tea seed from Japan through the renowned expert on things Japanese, von Siebold, and during the following years increasing quantities of both China and Japan seed were imported into Java. By 1835 about two million plants had been put out, largely due to the zeal of J. J. L. L. Jacobson, in the service of the Dutch Trading Company, who by reason of various visits to China, made in order to collect information on the cultivation and manufacture

of tea, had become one of the greatest experts on tea at that time.

The tea industry in Java did not advance steadily as in Assam, and it is only recently (since 1900) that Java teas have become an important factor in the market.

In 1832, the Dutch Company, realizing the possibility of tea as an industry, brought expert tea makers from China to work in Java, but the results were not successful. In 1838 an establishment for the finishing of tea was set up in Batavia, presumably in accordance with Chinese methods. Owing to difficulties of transport, the final treatment of the tea was often not given until several months after the preliminary manufacture, and this naturally caused serious deterioration in the quality of the product. The result was that tea sold at a loss which between 1835 and 1860 became so serious that the Government abandoned its direct connexion with the industry as existing contracts expired.

In 1865 several estates were rented to private individuals in the Preangers district and others were opened out, but the quality of the tea was still inferior and could not compete with that of British India. About 1878, hand manufacture was replaced by machinery and considerable improvement in quality thereby effected.

Assam seed was first imported in 1872 although the first real success with this seed was not obtained till 1878. It is reported that Assam seed was imported from Ceylon to Java as early as 1877, but as the plants proved scarcely different from 'Java seed' (as the China bushes grown in Java came to be known) the experiment was given up. During the tea rush of the '80s, more Ceylon tea was imported with no more encouraging results than before. The Assam plant has been so successful in Java that it has now become the standard type in the island.

In 1882 a society known as the Soekaboemi Agricultural Syndicate was formed with the object of looking after the interests of tea and allied industries in Java. During the '90s the Government took a great interest in tea, and deputations visited India and Ceylon, which led to changes in Java methods.

In 1905 a determined effort was made to improve the quality of Java tea, and to this end a Tea Expert Bureau was formed. In 1906 an Englishman was employed to help the planters to make the best of their tea. The expert had an office first at Soekaboemi and later at Bandoeng, from which towns he reported on tea samples and visited estates.

There is no tea market in Batavia comparable with those in London, Calcutta or Colombo, but European buying firms have established themselves there and buy much tea by private contract. However, owing to the sellers having insufficient knowledge of the commodity and being out of touch with European markets, these contracts were not always to the best advantage of the producer. Accordingly, in 1910 the Tea Expert Bureau took its present form and moved to Batavia.

Much of the Java tea is sold forward on the f.a.q. basis, and it is the duty of the expert to see that the quality is kept up to the standard, and to report any change of grade or shortcoming in the tea. In case of a dispute, the expert can act as arbitrator with two others. The expert is British.

Only Dutch firms belong to the Bureau, for British agencies have their own tasters. In 1928, 165 estates in Java and Sumatra were served by the Bureau, these including Arab and Chinese owned concerns.

In 1928 the Bureau cost about 70,000 guilders (£5,833 at par), this sum being raised by a contribution of 10 cents (2*d.*) per 100 kilos (220 lb.) tea made, a charge

of 25 cents (5*d.*) per sample tasted, and an annual subscription of 50 guilders for circulars on prices, reviews, etc. From the sum raised in 1928, £1,000 was set aside for propaganda, which was used for advertising Java tea in American papers and journals.

The average price of Java teas is considerably lower than that of India and Ceylon teas. This is in part due to the fact that in Java are more than 80,000 acres of *kampong* (Malay—village) and native tea plantations. These areas are generally put out without a factory and the leaf sold to estates with factories. *Kampong-blad* (village leaf) is mostly bought when the market is strong. *Kampong* tea is usually poorly cultivated and roughly plucked, although some of it, contiguous with European owned estates, is very good well tended tea.

Another factor tending to lower the average price of Java tea is the sale of a rough grade known as Bohea. This is only a small proportion, less than 5 per cent perhaps.

The earliest systematic scientific work on the subject of tea in Java was carried out by van Romburgh, Lohmann and Nanninga from the early '90s onwards, and these men laid the foundations of the science of tea. The work was carried out in the laboratories at Buitenzorg, connected with the famous Botanical Gardens.

In 1902 a Tea Experiment Station was founded with Nanninga as the first Director, followed in 1907 by Bernard. In 1926 the tea station came under the control of the General Agricultural Syndicate, formed by the amalgamation of the interests in rubber, tea, coffee, cocoa and cinchona. There is also a Scientific Department at Medan, in Sumatra.

The growth of the tea industry since the beginning of the present century is illustrated by the annual exports which are now given.

Export	Java	Sumatra
	million lb.	million lb.
1901	16·8	—
1910	40·6	—
1917	80·2	4·1
1924	105·1	17·9
1929	138·4	22·9

Thus in 1929 the Netherlands East Indies exported 161·3 million lb. tea as against 380·4 million lb. from India and 251·5 million lb. from Ceylon.

At the end of 1928 there were 202,000 acres under bearing in Java, and 235,000 acres planted. In Sumatra almost limitless tracts have been found suitable for tea. In 1911 only 500 acres were planted in this island, but the success was such a signal one that the area has rapidly increased. By 1928, 53,000 acres had been planted. Most of the Sumatra estates are planted near the east coast towards the northern end of the island, with Belawan Deli as the port and Medan as the business centre. Much of the tea is planted round Siantar, but areas on the west coast are also being opened out.

Sumatra has benefited by the experience of Java and planting is done on modern lines, whilst the factories are the finest in tea.

It is estimated that about 6½ million lb. tea are consumed annually in Java. The estate labour drink mostly Bohea. Of the tea exported, about 95 per cent is shipped from Priok, the port of Batavia. Great Britain, Australia, Holland and the United States are the main consumers. All the Dutch markets are rapidly expanding. In 1915 the imports into Great Britain were only 34·6 million lb., and in 1930 they had risen to 76·7 million lb.

The tea estates in Java and Sumatra are controlled by agency houses in the same manner as in India and Ceylon. The labour in Java is obtained locally, whilst that in Sumatra is recruited from Java.

The Tea Soils of Java

The oldest rocks, granites and shales, which make up the foundation of the island of Java, are very little seen on the surface because they were covered up during the Tertiary period with volcanic material. The formations of the Cretaceous period are also unimportant with regard to the present state of the island. The volcanic deposits of the Tertiary and later periods form the greater part of the present surface. During later geological times, the Eocene and Miocene periods, sandstones, conglomerates and breccias of volcanic material were formed. In the later Miocene period, clays, marls and limestones were formed.

Andesite and basalt give rise to about 75 per cent of the soils of Java, the older eruptive rocks forming soils are diabase and gabbro.

The classification of Java soils has already been discussed in the general chapter dealing with tea soils.

The mechanical analyses of the Java tea soils show them to vary over an extremely wide range, from gravels to very heavy clays. The soils fall into four broad types. First there are the very young volcanic soils which are gravelly and contain very little clay as a rule. Then come the young volcanic soils which have had more time to weather than the former type, and are often fine sands and silts, although many are very light. The older the soil the greater the percentage of fine particles, and some of these volcanic soils may contain as much as 70 per cent clay. The Pengalengan soils constitute the third type, and these resemble physically some of the young volcanic

soils and are generally silts. The striking characteristic of these soils is their richness in organic matter. The last type includes the geologically old soils which are usually clays.

The following table gives an idea of the constitution of the four types of soil discussed. The fractions are arranged according to Hall's limits for the size of each group of soil particles, in order that a comparison may be made with the examples of Indian tea soils which are given elsewhere, and were analysed according to Hall's method.

The Mechanical Analyses of Java Tea Soils

Soil type	Gravel	Coarse sand	Fine sand	Silt	Fine silt	Clay
	%	%	%	%	%	%
Very young volcanic	47	37	2	2	3	4
Young volcanic	7	32	31	11	14	5
Pengalengan	2	24	39	16	13	6
Old soils	nil	1	3	3	16	73

Turning to the chemical composition of the tea soils of Java, it is seen that the best contain about 1 per cent nitrogen, and the average about 0·35 per cent. They are by standards in India very rich soils. On the Pengalengan plateau the soils show an average content of organic matter of about 10 per cent.

The potash content of Java soils is very high, so much so that the application of potash manures is not necessary.

The phosphoric acid content is considered poor in the tea areas of west Java, although values vary widely. The available phosphoric acid is generally less than 0·01 per cent.

The total lime shows a wide variation and may be as little as 0·1 per cent or as great as 1 per cent. Java soils

are slightly acid. A soil with a pH value of 6·8 grows good tea, but the bushes on such a soil are subject to the root disease *Rosellinia arcuata.* Many of the soils show pH values circa 5·5.

Planting, Pruning and Plucking

About three-quarters of the tea in Java is situated on slopes and steep hills and most of the tea is planted at altitudes above 1,000 feet. On account of the irregularity of the land and because of the type of plucking, the extensive even sheets of tea which are the feature of North-East India are uncommon. The Java tea areas resemble in appearance those of Ceylon.

The tea plant in Java seeds all the year round, but most freely from November to January, and gives a total seed crop about the same as in India. Much Java seed is exported to Sumatra and Ceylon.

Most of the planting is done between the beginning of the rains and the end of February, and 14 months old plants are usual. The seed is put out in a nursery, shaded for preference, and the seedling is cut to about 6 inches before planting as a ' stump '.

About two years after transplanting, the bush is cut across at a height of about 20 inches, a little lower at the centre than at the sides. The bush is then pruned up, on an average every two years or so for the next 10 years, that is 5 times, after which it is cut back to about 20 inches.

On some gardens a ' skiff ' is given to the bush in place of a light prune and, although this gives leaf temporarily, the ultimate result of such treatment is detrimental. A ' skiff ' indicates a very light top prune which removes only the top leaves and makes no attempt to remove weak twigs.

After ordinary pruning in Java the bush is out of commission for 3 months, more or less according to the

age of the wood cut. The first plucking is made above three leaves, and then above one leaf for all subsequent pluckings. After heavy pruning, 'tipping' is done at a height of about 28 inches.

By closer plucking than that described above and by plucking to the *janum* or 'fish leaf' in the third year, the height of the bush can be kept down and pruning put off till the end of the third year. In such a case the plant takes longer to recover than if it had been pruned at the end of the second year.

Three leaves are generally plucked and a smaller shoot than this is considered to be immature. The plucking period is generally 10 or 12 days and sometimes longer.

Consistent plucking to the *janum* at a height of about 30 inches has been tried in Java and found to bring on Mosquito blight and Red rust. Such close plucking in Ceylon has also been found seriously to harm the bush and, indeed, in North-East India *janum* plucking on a 6-inch growth of new wood can only be practised year after year on strong tea.

MANURING AND CULTIVATION

The use of artificial manures in Java is not yet so extensive as in Ceylon and India. Mention has already been made of the quantities of manure added. The manures are broadcast at the time of hand forking, preferably a short time before the rains or before pruning. If chemicals are given one time, oil cake may be given the next. It pays best to manure good tea and on this account the general idea in manuring is first to get a good, humus-rich soil carrying a strong bush, and then to apply manure. It is suggested that poor tea should be rested under shade trees in order to strengthen it, in preference to be manured and plucked.

Cattle manure is not used to any extent, and in a country where an effort is made to control weed growth its use presents a serious difficulty, because it carries with it the seed of weeds. In Java as in Ceylon there is no drought severe enough to stop weed growth altogether for a period, as in Assam. Hence if weeds once get a hold on an estate it is a long process to eradicate them.

Green manuring by means of ground green crops and shade trees is widely practised in Java, and it is common for the whole estate to be under green crop at the same time. The older the garden and the closer the tea, the more necessary is it to supply organic matter from shade trees.

Of the shade trees the Ceylon sau is the best and most popular. The dadap (*Erythrina indica*) and *Derris robusta* are also common. Shade trees are closely planted, pollarded at about 12 feet, lopped and the loppings buried or left as a mulch. It is common to leave the shade up in the dry season and to lop it in the rains.

Of the ground green crops, *Tephrosia candida, Crotalaria usaramoensis, C. anagyroides, Indigofera endecaphylla, Calapogonium mucunoides, Vigna oligosperma, V. hosea* and *Leucana glauca* are at present most used. The last, which has deep roots, is much grown on hillsides. *Clitoria cajanifolia,* once very popular, is now not widely used.

The method of using green crops in Java is quite different from that in North-East India on account of the difference in climate. In the latter country one of the problems of the dry months is the conservation of soil moisture, and a clean soil, mulched by hoeing, is necessary to that end. In Java the green crop is left up as long as possible, and then cut and allowed to grow again. The cut crop is left on the soil as a mulch.

Some years ago clean weeding was practised in Java, but this process has now been replaced either by selective

weeding or by green cropping if the bushes themselves are unable to keep the weeds in some sort of control.

At present the consensus of opinion is against frequent soil disturbance, although the need to control weeds is recognized. Deep cultivation in the form of hoeing and trenching is not common, one reason against the latter is that if prunings are buried in trenches a tendency to the spread of the root disease Diplodia is observed.

Drains are not necessary in Java because the soil is so porous. Soil erosion is reduced by means of silt pits and green crops grown in hedges, although with the presence of ground green crops these precautions are unnecessary.

The hill slopes on tea estates are perfectly terraced, for the natives themselves are masters of this practice in their own cultivation. Sometimes the hillside is contour-planted with a green crop before the tea is put out, so that the terraces form naturally between the rows of crop.

Pests and Blights

Most of the fungi which attack tea in North-East India are known in Java, although they operate with different degrees of virulence.

Of the root diseases, *Ustulina zonata* (Charcoal stump rot) is common on all soils. *Rosellinia arcuata* (Black root rot) occurs on soils which are neutral or only faintly acid. *Fomes lamaoensis* (Brown root rot) occurs sometimes, but *Sphaerostilbe repens* (Violet root rot), a very common disease in India, does not attack tea in Java, although it is common on rubber and green crops. *Diplodia* (Die-back) also occurs.

Leaf and stem diseases are less common than in North-East India, probably on account of lighter

plucking. Brown and Grey blights are common but Blister and Copper blights are not known. Thread blights, Nectria and Corticium are known but are not common. Red rust is a very serious blight and often completely cripples weak or debilitated tea, especially after an attack of Mosquito blight.

Septobasidium rubiginosum is very serious and may kill out strong plants, both tea and green crop. *Septobasidium* spp. are found in North-East India but so far have not been observed parasitic on the tea plant. Its attack in Java has increased during the past few years and has spread from dadap and *Crotalaria anagyroides*. An attack by this fungus may be followed by Red rust.

It is considered in Java that the best safeguard against fungus attack is light plucking and generous cultural treatment.

The most serious pest in Java is Helopeltis (the Tea mosquito). The Pink mite is sometimes serious, but Red spider is not so common as in India. Thrips and other pests occur, but are not serious. Green fly is unknown.

Much interesting and useful work has been done on Mosquito blight in Java. The species of Helopeltis known in Java are *H. antonii* Sign., *H. theivora* Waterh., *H. cuneatus* Dist. and *H. cinchonae* Mann. *H. theivora,* the species doing damage in North-East India, is practically harmless in Java where *H. antonii* takes the greatest toll of the tea bush. At altitudes above 4,000 feet a different variety of *H. antonii* is found which prefers cinchona to tea. *H. cinchonae* has been known to attack tea.

According to observations it appears that the mosquito punctures the veins of the leaf and that immune bushes are harder in the veins than others. The mosquito cannot stand exposure to bright sunlight, and

dense shade encourages the pest. Many methods of combating this pest have been tried, including hard plucking, special pruning, hand catching, fumigation and spraying, with varying results, generally failure.

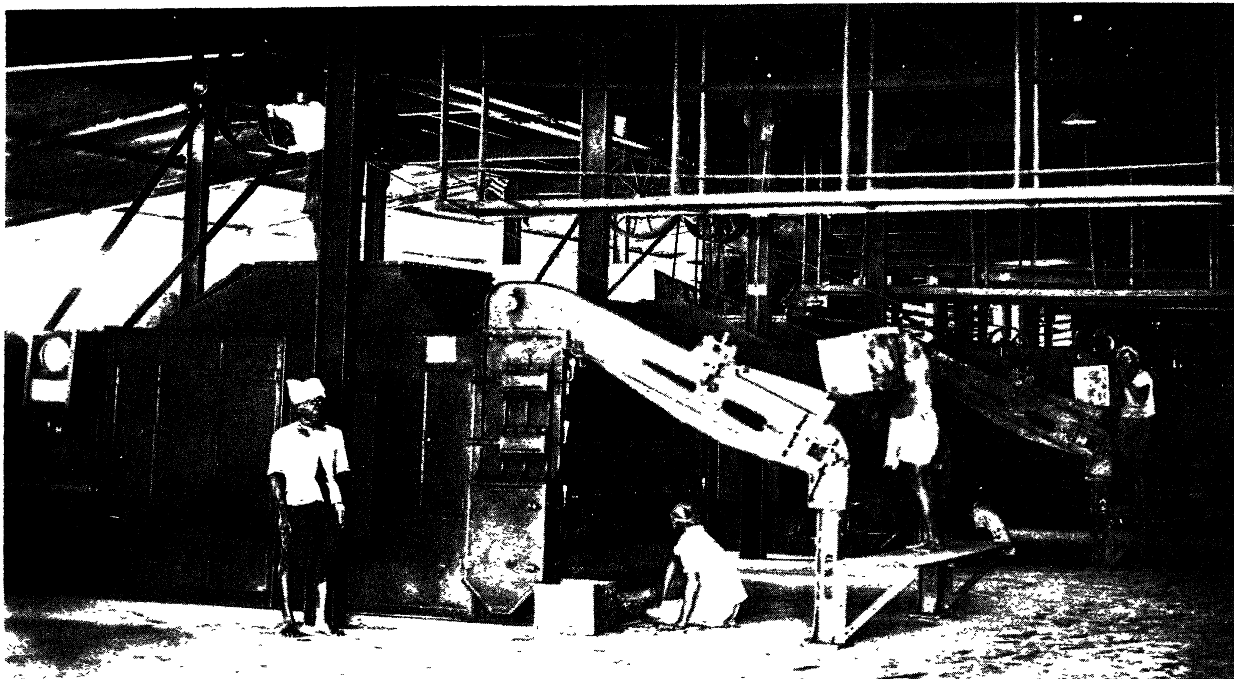
A few years ago the entomologist at the experimental station discovered a parasite of the Tea mosquito, *Euphorus helopeltidis*. The eggs of the parasite are laid on the first larval stage of the mosquito and, later, the cocoon of the parasite goes to the soil. A parasite of *Euphorus helopeltidis* has been discovered but it is rare. In North-East India a parasitic mermithid worm has been found, but its ravages of the Tea mosquito are not serious enough to warrant any hope that it may be used to control the pest.

On Tjiboengoer tea estate interesting experiments on the control of mosquito by pruning have been made. Briefly, the treatment consists in pruning alternate rows of tea in a block every two years. Only good areas of sound tea, from which the worst effects of the blight have been eliminated by previous good treatment, may be expected to respond to alternate-row pruning.[66]

This type of pruning has been tried on other estates, sometimes with success and sometimes failure. It has also been tried in North-East India but without success.

Mosquito in Java attacks at any time, but generally in February and March at the end of the wet season. The attack is aggravated by Red rust which often completely wrecks the frame of the bush just as the subsequent attack of Brown blight in India often finishes off the devastation started by mosquito. In Java it is observed that the weaker bushes have the axillary as well as the terminal buds attacked by mosquito.

[66] A full description of this work and a comprehensive account of the work on Tea mosquito in Java is given by H. Ashplant in *Report on Mosquito Blight* (Helopeltis) *of Tea in Java.*



A TEA DRYING MACHINE

By permission of Messrs. Davidson & Co., Ltd., Belfast

TEA MANUFACTURE

The tea factories of Java are run largely by hydro-electric power, and the hilly nature of the country and steady water supply are made use of to the fullest extent in this direction. In one or two cases tea is dried by air electrically heated.

The tea machinery in use, like rollers and dryers, is generally of British make, as are many of the sorting machines. Each machine is usually worked by a separate motor and the consequent absence of shafting and belting is a great advantage.

The leaf is withered in controlled lofts arranged in a manner similar to that employed in Ceylon. Wire racks are generally used and the leaf is spread rather thickly, at about 2¼ lb. to 10 square feet. On boards or hessian about 1 lb. and on plaited bamboo about 1½ lb. to 10 square feet is suggested.

The value of low temperatures in the withering loft is recognized and 82° F. is the ideal aimed at. The leaf is considered to be withered when it has lost from 10 per cent to 40 per cent of its original weight, according to the initial moisture content of the leaf. Thus it is advised that leaf containing 80 per cent moisture when it is plucked should dry till it has lost 40 per cent of its weight. On an average, 100 lb. leaf are dried to about 60 to 65 lb.

In the factories on the Pengalengan, at an altitude of about 5,000 feet, withering machines invented by the late Mr. Bosscha, of Malabar tea estate, are often used. The machine consists essentially of an octagonal cage about 10 feet long, each side of the octagon being about 20 inches long, with a central arrangement for blowing in hot air.

After the leaf has been well withered on the racks it is placed in the withering machine. Enough to serve

one roller constitutes a charge, and the leaf is then submitted to a hot air blast at about 120° F. for about 30 minutes, whilst the machine rotates at about 35 revolutions per minute. At the end of half an hour one side of the machine which acts as a door is opened, and as the machine continues to revolve the leaf is flung out and thus cooled. During the whole process the leaf loses 3 per cent to 4 per cent moisture, becomes limp and takes on a reddish-brown colour and develops a strong smell of fruit.

It is claimed that these machines make the wither regular throughout the shoot and reduce the time of fermentation from 6 or 7 hours to 3 hours. Only one Bosscha Withering Machine is in use in North-East India, in a garden in the Surma Valley. Here it has been found that the fermentation time is reduced from 3 hours to about 1½ hours, and the amount of red stalk in the finished tea is lessened.

In Java the rollers revolve slowly, making only 40 to 50 r.p.m. in the first roll, the idea being that slow rolling preserves the 'tip'. The second roll is sometimes made at a faster rate than the first.

In the fermenting room some modern form of humidification is generally used. The leaf is spread thinly on racks in a fresh atmosphere which is cool and humid.

Firing is usually carried out in one process in about 25 minutes, at temperatures varying from 175° to 212° F. The lower temperatures are considered preferable so far as quality is concerned.

Wood, and in a few cases oil, are used for firing. At Malabar estate firing is done electrically, and it was found during the earlier trials that the power consumed by a large E.C.P. machine was as much as 160 kilowatts. After the stove of the dryer had been redesigned and the

leaks in the body of the machine stopped to avoid all unnecessary air loss, the required power was then reduced to about 110 kilowatts.

The firing machines in Java are insulated by plates of asbestos or some such compound which leave a foot of air space round the stove. These are so arranged that the air entering the heater has to pass through the space between the plates and the stove. In this manner, loss of heat by radiation is greatly reduced and a fuel saving of 25 per cent or more is realized as compared with the consumption in a machine not so insulated.

All stoking of the dryers is done outside the factory, and this precaution against dust and untidiness is in keeping with the general cleanliness of Dutch tea factories.

The atmosphere of the sorting room is kept clean and free from dust, and to this end a dust extractor which carries off fluff is installed above each sorter. Largely as a result of this, Java teas are very clean in appearance.

Java tea is packed containing 7 per cent to 8 per cent moisture, as estimated by drying the tea at a temperature of about 105° C.

JAVA TEAS

Java teas generally lack flavour and strength, and the liquors are coloury and soft. There is little 'tip', although the teas are very well made and clean, and the leaf is black and well twisted.

The quality period in Java is from mid-June to mid-October, the dryer season, when some flavour is noticed. For the rest of the year the teas are common and plain. Even the high-grown teas show little flavour although they are brighter and brisker than the low-grown. The poorest months are from November to April, the wettest period.

There are several reasons why Java teas are lower priced than those of Ceylon and India, one of which, the manufacture of *kampong-blad,* has already been discussed. In addition, the climate is against true quality periods, for there is no marked seasonal change, which is apparently one of the factors necessary for the development of marked flavour in the leaf.

The method of plucking customary in Java is long and coarse, and is not conducive to the production of quality tea. It must be remembered, however, that it is not necessarily economically sound to pluck finely and to make fine teas. That Java can make good tea, if necessary, has been shown in the present slump (1932-33) when the average standard of Java teas has greatly improved. This improvement is due mainly to finer plucking.

PART IV

THE BRITISH TEA TRADE

Chapter XIX

THE MARKETING OF TEA

The tea markets of the world—The London tea sales—Tea blending—The distribution of tea.

Much of the information contained in this chapter is taken from the Eighteenth Report of the Imperial Economic Committee, published in 1931, which deals with tea, and the Report of the Food Council, published in 1925.

The Tea Markets of the World

There are tea markets in all countries where the commodity is produced on a large scale. In China the greatest tea mart is Hankow, where the produce of the Yang-tsi Valley is collected and sold. Hankow is also the centre of the Russian brick tea trade. The teas of the Fu-kien Province are largely sold at Foochow, and the green teas of North China at Hangchow and Ningpo. Of recent years the importance of Shanghai as a tea centre has been increasing. The brick tea trade of Tibet and Mongolia is centred chiefly at Yochow.

The tea trade of Japan is carried on at Shizuoka, and that of Formosa at Taikohu, at both of which places European buyers are established.

Much of the Java tea is disposed of at Batavia by private treaty. Almost half the tea from the Netherlands East Indies is sold in London. Regular auctions are held in Amsterdam.

At Calcutta and Colombo regular tea auctions take place, and the tea sold is either consumed locally or shipped direct to its destination, especially to Australia,

New Zealand, the Far East and America. The trade of the North-West Frontier of India is carried on largely from Amritsar.

In Europe the tea centre is London where auctions are held on four days of the week. On Mondays and Wednesdays, India teas are sold ; on Tuesdays, Ceylons ; and on Thursdays, Java and Sumatra teas. China tea is sold by private treaty.

The tea sales are conducted in the sale rooms in Mincing Lane in the City of London, and most of the tea business is transacted in offices nearby. London is the world's tea market and the centre of the trade. In 1929, of a total export of tea from all countries of 866 million lb. no less than 559 million lb. came to London, of which 95 million lb. was re-exported. The value of the total tea imports in 1929 was £36·5 million.

The tea trade is largely a concern of the British Empire. Over 70 per cent of the tea exported is produced in the Empire, and nearly 70 per cent is consumed by the Empire. Over two-thirds of the entire capital engaged in tea production are provided by the Empire. All the machinery employed in India and Ceylon is of Empire origin, and over 60 per cent of the chests used for the transport of tea are imported from Empire countries.

The magnitude of the tea industry can be judged from the fact that to-day tea forms in value 1 per cent of the total merchandise entering world trade.

The London Tea Sales

Tea is dispatched by the estate manager to the local port where the managing agents of the estate consign it to the representatives of their firm in London. When it reaches the London docks it is put into bonded warehouse (assuming there is a duty on tea), and is put up

for public auction by selling brokers who act for the tea dealers and distributors.

The selling brokers draw samples from each 'break' and examine them and issue catalogues in which the garden mark, number and kind of packages, weight and grade of tea is described. If the 'break' is found to be uneven it is unpacked and rebulked in the warehouse. The buyers also draw samples which are tasted and evaluated, and by the day of the sale both buyers and sellers have formed their ideas of the value of the tea. The stock situation and market demand are so well known to both sides, and tea tasting has become such a fine art, that the respective evaluations are usually fairly close.

The selling broker usually has the order to get the best possible price for the tea without any reserve, but if a lot is withdrawn he (the selling broker) endeavours to dispose of it later to the highest bidder at the auction by private treaty. The latter often 'meets' the seller at a price somewhere between his bid and the current market value of the kind of tea withdrawn.

Selling brokers also do business on behalf of purchasers whose orders they have received before the auction. The sellers have 'market men' who appear in the box with the selling broker and bid as other buyers in the room. Business of this type is usually done on behalf of smaller buyers dealing with the Continent. The selling broker receives 1 per cent commission on his sales and his 'market man', also his employee, gets one-half per cent commission from the purchaser.

It might be thought that the 'market man' would be unable to work in this dual capacity without prejudice to the interests of either seller or buyer, but the necessity to retain the confidence of both sets of clients and the

fact that the general current value of ordinary teas (excluding flavoury or exceptional parcels) is well known, ensures that the arrangement shall act fairly to all parties.

The immediate purchasers at the tea auction in Mincing Lane are the buying brokers who number about a dozen and are members of the Tea Brokers' Association in London. About six of these do the bulk of the buying. The buying brokers buy tea to re-sell later to dealers, blenders and merchants at a commission of one-half per cent on the purchase price.

Although the auctions are public and nominally anyone can bid, any unknown or unrecognized buyer or any distributor who instructed his buyer to bid directly and not to buy through the intermediary of a buying broker, would have the price run against him. Accordingly, all purchases are made either through buying brokers or the 'market men' of selling brokers.

The bidding is done in pence and farthings per lb. and the same price is often bid by several buyers, each of whom is unwilling to raise the offer. The parcel then goes to the first bidder who often shares his purchase with the other bidders who pay their proportion of the brokerage.

The buying broker often buys teas for which he possesses no order. Such teas are placed in the 'bought over' list which is issued daily, and from this list dealers, blenders and other distributors can select the teas they require. In this way the buying broker enables the small dealer to obtain the teas he wants in quantities which are too small to be dealt with at the auction.

It might be considered that the buying broker is an unnecessary link in the chain of distribution, and that his intervention merely increases the cost of the tea by one-half per cent. Two reasons for his existence are,

however, put forward. The first, already mentioned, is that small buyers are able to purchase small parcels from the 'bought over' list instead of having to purchase a much larger quantity at the auction. In this way bidding is reduced with the resultant lower sale price, and the small buyer has a wide range of teas to select from. The second reason is that the buying broker acts as a cover to the nature and magnitude of the trade of his client. If a distributor bought openly in the auction, his competitors might gain knowledge which they might turn to their advantage and which might lead to a loss in trade. Although the large distributors attend the auction, they do not actually bid. If the buying broker were eliminated, the big distributors might combine to drive out the smaller concerns which at present buy anonymously through the broker.

It is estimated that about 70 per cent of the home distributing trade is in the hands of four combines, and although competition is keen, and the prices thereby kept up, the temporary absence of one of these concerns from the market leads to wide fluctuations in price. Such changes are undesirable to the growers, for they are tempted in a period of inflation to produce more tea by coarse plucking, which when it is offered may meet a flat market.

The Associations of the tea producers have attempted by various means to stabilize prices. Thus the Indian Tea Association has arranged that the offerings of India teas shall be spread evenly over the season, although more than half the crop is produced in three months. Forward sales are discouraged, owing to the loss which the producers sustain if the market rises. Although the agreement to abstain from forward sales lapsed in 1929, the practice has not been renewed. On the other hand, such sales are encouraged in Java, and with other crops

the forward sale is considered to have a steadying effect on prices.

It has been urged that the producers should combine to form a selling agency, such combination being effected through the agency houses which act as merchant bankers to the concerns they manage. Although the need for such a combination is recognized, the wide differences between the teas from various districts and from individual gardens makes its formation difficult. This necessary development will, no doubt, come at some future date.

Tea Blending

Several characteristics go to make up a good tea, some of which are flavour and aroma, pungency, strength and body. As the tea is produced on the garden it may be richly endowed with one quality and lacking in others. Accordingly, teas are blended to give a nice balance of all the desirable properties. Another reason for blending tea arises from the necessity of supplying a demand for tea of an approximately uniform quality at a stable price. Practically no unblended tea reaches the consumer.

The blending of tea is done by a tea taster, and since the product of every garden is constantly changing, it follows that the particular garden teas which make up a blend must also vary, although the qualities of the blend are fairly constant. A taster's power of discrimination is highly developed, and he can make up blends from a diverse collection of teas to match other blends or to match blends made the week before.

Well known and widely advertised proprietary blends must be kept at a stable price, and when the price of the better teas which give flavour and quality to the blend rises, the price of the blend is kept down

by adding a greater proportion of cheap tea known as the 'filler'. This is a low priced common tea which does not contribute to the quality in any way but, provided it is fresh, will not do any harm except to act as a diluent to the finer qualities of the blend.

Provided it is not overdone, the 'filler' may be used to stabilize the retail price of a blend throughout a fairly wide range of wholesale price fluctuations.

Java teas and the commoner India and Ceylon teas are used as 'fillers'. Hence it will be seen that a general high price for tea increases the call for non-British teas unless there is a plentiful supply of Empire grown good medium tea available at a low cost.

In blending teas for some markets, particular attention must be paid to the appearance of the tea. For example, parts of Ireland take large quantities of fine 'tippy' teas, whilst the United States and the Continent prefer whole leaf to broken grades. Very recently, however, both Ireland and the United States have begun to recognize the importance of the liquoring qualities of the tea rather than the appearance.

The Distribution of Tea

Some years ago it was the custom for the dealer to supply the original chests to the distributor or retailer who made his own blends. To-day it is usual for the dealer to be replaced by the blender who blends tea wholesale and distributes it to the retailer either loose or in packets. The great bulk of the packet tea thus sold is a proprietary article, and may be sold through the chain stores of a multiple shop organization or through other shops.

The large scale distribution of packets ensures a constant fresh supply to the retailer, who is able to work with a minimum of capital since the wholesale blenders

maintain a weekly delivery of packets. Another benefit, and one seldom realized by the small blender of the past, is the evenness of the blend. The big blenders are able to distribute their purchases over a very wide range of teas and as a result are able to put out a blend of constant quality.

One result of blending is that the purchaser is no longer able to buy, for instance, a Dooars autumnal, an Assam second flush or any particular seasonal or district tea, and the grocer himself becomes a middle man with no personal interest in the tea he sells, such as he would have if he had constructed the blend himself. This tendency is by no means confined to the selling of tea.

If a grocer wishes to build up a business with non-proprietary blends he is catered for by certain big blenders who also distribute a parallel range known as grocer's blends. Several sample blends are sent to the grocer who selects those suitable to his requirements regarding price and quality, and this blend is supplied to him as required. This procedure has the advantages given by the sale of proprietary blends and also allows the grocer to exercise his personal judgement in selecting the teas he wants to sell.

CHAPTER XX

TEA PRODUCTION AND CONSUMPTION

World production and export—World consumption of tea—The wholesale price of tea—The future of the tea planting industry.

IN this chapter the world production of tea is discussed and the problem of its disposal examined. Much of the information which follows is taken from the Eighteenth Report of the Imperial Economic Committee. Many of the statistics appear in earlier chapters and have been assembled here for comparative purposes.

WORLD PRODUCTION AND EXPORT

Neither the acreage under tea in China nor the annual tea production in that country are known. Estimates of the latter usually vary between 600 and 1,000 million lb., although one estimate puts the figure as high as 2,000 million lb. In Formosa it is known that the Chinese consume about 2 lb. tea per head per annum, and it is sometimes assumed that in China consumption is at a similar rate.

Some mention has already been made of the decline of the export tea trade of China during recent years. The loss of the tea business by China and the gain by India, Ceylon and, later, by Java is one of the most amazing occurrences in the history of eastern trade.

The year 1886 saw the peak of the China tea trade, with Britain still dominating that market. From this time the trade declined, but Russia took Britain's place and brick tea largely made up for the loss sustained by leaf teas. This second phase in the China tea trade reached its climax in 1915, after which the War and the

Russian Revolution stifled the brick tea trade till in 1924 it was only a fraction of its former size.

The table shows the exports of black, green and compressed tea in million lb. in the years 1886, 1915 and 1924.

Export of Tea from China in million lb.

Year	Black tea	Green tea	Brick, tablet and dust	Total
1886	220	26	49	295
1915	103	41	90	234
1924	54	38	9	101

The way in which the trade with Great Britain and the United States was lost first and then that with Russia, is illustrated in the next table which shows the chief importing countries in the years 1886, 1915 and 1924. Although Great Britain still imports a considerable quantity of China tea, most of it is re-exported, and the consumption within the country is less than 10 million lb. per annum.

The Import of China Tea in million lb.

Year	Great Britain	Russia	U.S.A.	Others
1886	170	80	40	5
1915	47	155	18	14
1924	54	7	11	29

Statistics of the tea industry in Japan and Formosa are available. The acreage under tea in Japan is about 120,000 and in Formosa about the same. The annual production of tea in Japan is about 80 million lb. and of Formosa about 27 million lb. The combined export of both countries is about 27 million lb. Practically all the tea exported from Japan is green, whilst that from Formosa is largely Oolong.

The tea industry in Java and Sumatra is expanding rapidly. In 1928 there were 288,000 acres planted and the exports amounted to 153·5 million lb. In addition there were in Java in 1928 some 83,000 acres under cultivation by native growers. In 1932 the exports from these areas amounted to 173 million lb.

The tea production figures for India are given in the next table, and it will be seen that over the past 30 years the crop has almost doubled.

Tea Production in India

Year	Area under tea	Production in million lb.
1901	524,000	201
1922	709,000	274
1924	714,000	375
1928	773,000	404
1931	807,000	394

Tea is produced over an extensive area in India. The distribution of acreage and crop according to provinces was as follows in 1931 :—

Production of Tea in India in 1931 *by Provinces*

	Acres	million lb.
Assam, Brahmaputra Valley	286,668	172·07
Surma Valley	144,336	71·16
Bengal (Dooars, Darjeeling, Chittagong)	199,081	88·48
Behar and Orissa (Ranchi, etc.)	3,642	0·89
United Provinces (Dehra Dun)	6,254	1·37
Punjab (Kangra Valley)	9,693	1·90
Madras (Nilgiris, Wynaad, Anamalais)	72,351	27·51
Mysore	4,555	0·25
Coorg	415	0·17
Tripura (Bengal)	8,552	1·61
Travancore (High Range, Peermade, South)	71,886	28·67
Total	807,433	394·08

The production in Ceylon is next shown. The acreage for 1929 includes small holdings which are estimated at about 20,000 acres. The exports from Ceylon were 252 million lb. in 1932.

Tea Production in Ceylon

Year	Acreage	Export in million lb.
1901	406,000	144
1921	418,000	161
1924	440,000	204
1929	470,000	251

Tea has been long established in Natal and Nyasaland, but Kenya and Tanganyika are comparatively new ventures. In 1930, 9,000 acres had been planted in Kenya and extensive grants taken up. The acreage in this country may extend rapidly.

The acreage and production in the African tea areas in 1928-29 are shown in the next table.

Tea Production in Africa in 1928-29

	Planted area	Production in thousand lb.
Natal	2,000	800
Nyasaland	8,900	1,745
Kenya	5,600	150

In Georgia, Trans-Caucasia, the Government and the Consumers' Co-operative Society (Centrosojus) are devoting considerable sums to the development of the tea industry, which is administered by the Georgian Tea Trust established in 1925. Some 50,000 peasant families are engaged in tea cultivation, and the Trust has established two extensive State farms, partly for tea.

Research stations have also been set up. By the end of 1933 it is estimated to have 90,840 acres under tea and by 1940 the production is estimated at 46 million lb.

The exports of tea from the chief producing countries of the world are shown in the next table. The figures refer to the year 1929.

World Tea Export in 1929 (*in million lb.*)

China (black and green) ..	73·0
Japan and Formosa	32·8
Java and Sumatra	161·3
India	380·4
Ceylon	251·5
Africa	1·8
Total	900.4

At the end of 1932 it was estimated that 180,000 acres of young tea were coming into bearing. Much of this is in south India and Sumatra. In 1928-29 the area under tea, excluding China and Trans-Caucasia, was about 1,870,000 acres. The area in bearing in 1933 will thus probably be well over two million acres in the countries under discussion.

World Consumption of Tea

About half the world's export of tea is consumed in the United Kingdom. The next largest consumer, although far behind, is the United States of America, followed by Russia, Australia and Canada. The details of consumption for the chief countries in 1929 are shown below.

It is estimated that in Russia in normal times the annual consumption per head in the towns is 3·7 lb., in the villages 0·37 lb., in Siberia 1·8 lb. and in Russian Central Asia and Turkestan 2·7 lb.

Table showing Total Annual Consumption and Consumption per head of Tea in 1929 in 14 countries

	Total consumption million lb.	Consumption lb. per head
United Kingdom	421·3	9·20
United States of America	88·8	·75
Russia (including brick tea)	64·7	·60
India	57·0	·18
Australia	49·0	8·15
Canada and Newfoundland	40·4	4·15
Irish Free State	23·6	7·90
Holland	23·4	3·10
Egypt	14·3	1·02
Persia	13·0	1·30
New Zealand	11·9	7·90
Germany	11·7	·18
Morocco	11·6	2·31
South Africa	11·5	1·43

The consumption of tea in the United Kingdom has shown a steady increase during the past century, not only with the increase in population but also in consumption per head. Since 1911 the consumption has risen from 6·48 to 9·20 lb. per head, an increase of over 40 per cent in 20 years. The table which follows shows the consumption at certain periods since 1841, together with the population of the United Kingdom at the same periods.

Year	Population of United Kingdom millions	Consumption lb. per head	Total consumption million lb.
1841	26·7	1·37	36·6
1891	37·8	5·36	202·6
1901	41·9	6·17	258·5
1911	45·2	6·48	292·9
1921	47·1	8·68	408·8
1929	45·7	9·20	421·3

The last year excludes the Irish Free State.

This steady increase in consumption is due partly to the spread of the tea habit and partly to the more wasteful use of the commodity since it has cheapened in price. Whether the rate of increase observed since 1921 can be continued or whether any increase at all is possible is a matter for conjecture, for it must be remembered that according to some observers a stationary population is almost in sight.

In addition to the fact that the chief market for tea appears to be approaching saturation point, a further danger to Empire tea comes from outside competition. Although very little China tea is now consumed in Great Britain, its place in the Home market has been largely taken by teas from the Netherlands East Indies. During the past decade the amount of tea from Java and Sumatra consumed in Great Britain has increased enormously. The following table shows how the various tea countries have contributed to the tea consumed in the British Isles in recent years.

Tea Consumed in the British Isles, in million lb.

Year	India	Ceylon	Africa	Netherlands East Indies	China	Total
1920	234·2	107·5	0·8	36·6	10·8	389·9
1925	241·8	109·8	1·4	42·4	6·7	402·1
1930	238·3	126·2	2·8	76·7	9·0	453·0

During most of this period the teas of the Netherlands East Indies, as well as those of China, have been handicapped in the Home market by a preferential tariff given to Empire teas. In 1923-24 this preference amounted to a little over a penny a lb., and from 1925 to 1928 to

two-thirds of a penny a lb. In 1929 the tax on tea was removed and with it the preference, but in 1932 a tax of *2d.* per lb. on Empire tea and *4d.* on foreign teas was imposed. This preference has so far failed to keep Java teas from the Home market and now certain dealers consider them an essential part of some blends.

Even if foreign teas were kept completely out of the Home market by prohibitive taxation, competition from such teas would only become keener in other markets. It is thus becoming more and more evident that any successful attempt to regulate the tea market in order to stabilize prices at an economic level must be based on concerted action by the tea industry as a whole, British and foreign. Foreign tea is taken in this case to be that of the Dutch Indies.

The question of improving the market by restriction of crop is discussed later. It may here be remarked that restriction is a palliative giving relief temporarily, and that the only real way out of the difficulty is to seek new markets for the commodity. A brief survey of the potentialities of the great tea markets is instructive.

As already indicated, the United Kingdom offers only a limited scope for the expansion of sales. The United States, however, is a market of promise. Although the annual consumption has been about 90 million lb. for some years, the kind of tea constituting this total has shown a change in that green teas have steadily given place to black. Of recent years, as a result of the vigorous propaganda of the Indian Tea Cess Committee, the consumption of India teas has rapidly increased in the United States. This market may be regarded as one likely to expand considerably in the near future.

Canada is another market which offers much scope and here, as has been observed in other countries which

have developed the tea habit, the change from light liquoring teas to a preference for teas with body and strength is taking place.

The Australians are heavy tea drinkers already as is also the case with New Zealanders. Any marked increase in consumption in these countries will probably depend largely on an increase in population.

Before the Revolution, Russia was the second largest importer of tea in the world. In the pre-war quinquennium Indian exports of tea to Russia were, on the average, two and a half times as great as those to Canada i.e. 35 million lb. to Russia as against 14 million lb. to Canada. Russia has now fallen behind the United States but still ranks third as an importer of tea. It is a mistake to imagine that Russia has ceased to be a tea drinking country. In 1927-28 the total imports of tea into Russia were 65 million lb. in contrast with 172 million lb. in 1914. Although this is an enormous drop, it shows an increase of 34 per cent on the figures for 1926-27. Over half the tea imported into Russia in 1927-28 was in brick or tablet form. Of the rest, about 18 million lb. came from India and Ceylon. It is impossible to forecast the future developments of the Russian market, but with Russia able to purchase tea on the pre-War scale there would be no surplus and no talk of restriction.

Another potential market, as yet practically untouched, is India. The population of this sub-continent is 350 millions. The general development of the tea habit, even to a mild degree, which is practically bound to come at some future date, will be sufficient to absorb all the extra tea produced by any reasonable extension of the present acreage. Although the exact figure for the consumption of tea in India is not available, the official estimate of the Department of Commercial

Intelligence of Statistics is a reliable one. Over the past few years this figure has been as follows.

Consumption of Tea in India

	million lb.
1919–20	30
1924–25	44
1928–29	57

The Wholesale Price of Tea

The wholesale price of tea, like that of any other commodity, is regulated by the law of supply and demand. Apart from smaller price fluctuations, there have been within the past 30 years three major slumps in the tea market. The first began in about 1900 and lasted for about five years. This slump had its origin in a period of prosperity which led to the opening up of much new tea from about 1895 onwards. These areas came into bearing in about 1900, and until the market expanded to take the fresh supplies, poor prices were obtained.

The second slump came in 1920 and followed a long period of prosperity, including that of the War when in 1917 and 1918 prices were 'controlled' by the Government. In 1919 the control was removed, and in 1920 the Government of Britain released stocks which had been held up during the War. In addition, stocks which had been held up at ports for lack of shipping facilities began to arrive.

It is usual for wholesale tea prices to rise in the autumn with the arrival of the new season's crop. In 1920 this rise did not occur but the price fell from $15\frac{3}{4}$*d.* per lb. for common tea to 5*d.* per lb. in December of that year, a price comparable with that realized in 1908 when production and other costs were much lower. In 1920, by general agreement, the crop was restricted, by which means, aided by unfavourable weather, stocks were reduced. During 1921 prices remained low, but

a recovery came in the autumn, which was followed by a steady and general rise.

In addition to low prices, another factor which badly hit sterling tea companies in India was the rise in the value of the rupee, which in 1920 went above 2*s.* 10*d.* against the normal exchange rate then of 1*s.* 4*d.* Thus Home companies sending remittances to India had to find more than double the amount of sterling necessary under normal conditions.

From 1923 to 1927 prices were good, especially in 1924, 1926 and 1927. In 1928 a decline set in which continued till 1931, when tea in common with other commodities slumped still further. The year 1932 produced bumper crops and prices again declined. This last fall was much more serious than that of the immediate previous years, since not only did the price of common teas fall, but also the best, and the market failed to discriminate adequately between good and bad teas. There was thus little incentive to pluck fine leaf and many gardens made big crops with a view to reducing the cost of production. This led to a further fall in prices.

Average Wholesale Price of Tea, in Mincing Lane, 1922-1930, *in pence per lb.*

Year	North-East India	South India	Ceylon	Java	Sumatra	India B.P.S.
1922	15·5	14·0	15·8	10·1	11·2	13·1
1923	18·8	18·1	19·4	14·9	16·5	16·9
1924	19·9	19·0	20·8	15·5	17·9	17·3
1925	17·7	17·6	20·1	12·8	16·6	14·2
1926	19·4	19·0	20·3	13·7	16·0	17·0
1927	19·0	18·9	20·8	13·7	16·0	15·1
1928	16·5	15·4	19·0	12·6	13·9	14·3
1929	15·7	15·4	19·0	12·1	13·9	10·5
1930	14·7	14·5	18·6	10·2	11·2	9·0

The table above shows the prices averaged by teas from various countries between 1922 and 1930. In the last column the price of India Broken Pekoe Souchong is given, this grade being regarded in the market as typical of the cheaper teas. It forms 10 per cent to 15 per cent of the Indian crop. The price of this grade moves more rapidly and with less provocation than that of the better grades.

In 1931 the average price of India B.P.S. fell to about 6½*d.* During August of this year the price of common tea on the London market was only 4½*d.* per lb. In 1932 the average was a fraction over 6*d.*, but in 1933, with a scheme of restriction under discussion, prices rose steadily till they reached about 10*d.* in the middle of the year.

The price of tea is largely governed by the supply and demand balance, which is gauged by the stocks held in the London warehouses where about 90 per cent of the tea stock in the United Kingdom is stored. The total stocks held at the end of the years 1927 to 1932 were as follows :—

1927 stocks	.. .. ..	239 million lb.
1928 ,,	.. .. ..	233 ,,
1929 ,,	.. .. ..	275 ,,
1930 ,,	.. .. ..	288 ,,
1931 ,,	.. .. ..	270 ,,
1932 ,,	.. .. ..	303 ,,

By the end of 1930 the stocks in London represented more than 6 months' supply, a dangerous position since in that period many of the teas begin to 'go off'. In the following year, although stocks were reduced slightly, the market continued to fall, which indicated that a new factor, the general fall in the price of all commodities, was acting with greater force than those representing the internal conditions of the tea industry.

Bumper crops in 1932 again pushed up stocks which rose to well over 300 million lb. By this time, however, as mentioned above, a restriction scheme was well on the way to realization so that, in spite of huge stocks, prices steadied and then rose.

By 1929 the profits shown by tea companies was already below those of the last pre-War years. The profits of 65 Indian tea companies in various indicative years were as follows :—

Profits of 65 *Indian Tea Companies*

	1913	1924	1928	1929
Average profit per mature acre	£6–10–7	£15–2–0	£10–0–0	£6–9–0
Average profit in pence per lb.	2·6	6·4	3·8	2·3
Average crop per mature acre	599 lb.	560 lb.	625 lb.	684 lb.

These profits are very slender in view of the fact that under present conditions the capital value of a mature tea garden in the Brahmaputra Valley is about £100 to £120 per acre. Thus in 1929 the interest on the capital only averaged about 6 per cent, which is not considered sufficient for an agricultural venture in the tropics. In the latter phases of the slump these profits, small albeit, have dwindled and in 1932 few concerns made any at all and many made a considerable loss.

Losses cannot be borne indefinitely, and it is often suggested that the situation should be allowed to work itself to a natural conclusion, and that the weaker companies with insufficient reserves to tide them over the slump should go out of production. In practice, what happens is that such gardens are bought up cheaply and kept going somehow till times improve. On the

other hand, many observers think that the present condition of the market is only a temporary one and that demand will increase either from Russia, India or America, or that by reducing manuring the crops will be reduced and the market right itself. Accordingly, to tide over the present difficulties restriction has been adopted.

Restriction has been practised before. In 1920 the situation was eased by curtailing the plucking season by agreement between the producing countries.

In 1930, growers in Ceylon, India and Java agreed to a restriction of 57½ million lb. on the total output. The method of restriction was settled by each country, and that adopted consisted of reducing the crop of each company according to the quality of the tea it produced. Quality was judged by the average price obtained by each company or garden over the seasons 1926-27-28. If the price obtained during that time was less than 1*s*. 5*d*. per lb. on the London market the output was limited to 85 per cent of the 1929 crop. If the price was above 1*s*. 5*d*. and below 1*s*. 7*d*., 90 per cent of the 1929 crop was allowed. If the price was between 1*s*. 7*d*. and 1*s*. 9*d*., 95 per cent was allowed. For higher prices 97 per cent was allowed.

These restrictions were fixed in accordance with the fact that in most slumps the poorer teas suffer most and are in greatest need of restriction.

The scheme was only a partial success in that the total exports were reduced by 41 million lb. instead of 57½ million, owing partly to the unexpected reduction of the sale in tea in India and to the inability to control shipments of tea from Java by Chinese merchants.

With the continuance of the slump throughout 1931 and 1932, drastic steps were taken at the end of the latter year to reduce stocks. A scheme was worked

out whereby the export of tea should be reduced to 85 per cent of that in any of the three years 1929, 1930 or 1931. The agreement was made between India, Ceylon and the Netherlands East Indies, and the reduction of 15 per cent was calculated to put about 120 million lb. tea less on the market in 1933. In addition, the extension of tea areas was to be curtailed or held in abeyance. The ultimate results of the scheme, which is to hold in some form for five years and is to be modified if necessary from time to time, have still to be seen, but the early effect on prices has been, as already indicated, highly beneficial.

The Future of the Tea Planting Industry

Although the tea planting industry has experienced a number of booms and slumps in the past forty or fifty years, it has come to be regarded as one of the most stable industries. Tea shares are bought as an investment and seldom for speculation.

In the last thirty years the organization of the industry in India, Ceylon and Java has steadily improved. The troublous times following on the Great War have witnessed further improvement in this direction, largely along international lines. The three major producing countries confer on matters of marketing and the regulation of crops and exports, and in future it is likely that propaganda in favour of tea and the introduction of the commodity into new markets will be dealt with on an international basis. There is at present a free interchange of ideas regarding methods both in field and factory between the various tea countries.

Although the industry is highly organized, few observers, in view of the statistical position in 1932 combined with the general trade slump, would have predicted such a dramatic change in the situation as has been observed between December of that year and the

present time (August 1933). Although some rise in prices was inevitable only the most optimistic expected the value of common tea to be almost doubled during the period mentioned. This change was due, in part, to the general rise in the price of all commodities but in the main resulted from the measures taken to regulate output.

The slump which is now passing was predicted several years ago when it became obvious that the rate of planting and production were rapidly outstripping demand. With the experience gained in the past few years this state of affairs in an acute form can be avoided in the future. Minor fluctuations in the market are inevitable but the violent movements experienced in the past decade can be obviated.

It is tempting to end this account of the culture and marketing of tea on an optimistic note and to indulge in the luxury of prophecy. After making allowance for this inclination, the conclusion is reached that the tea planting industry is about to enter upon a long period of prosperity and stability.

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